THE FISH RESOURCES OF THE EASTERN CENTRAL ATLANTIC

PART ONE: THE RESOURCES OF THE GULF OF GUINEA FROM ANGOLA TO MAURITANIA

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PREPARATION OF THE DOCUMENT

This document has been prepared at the request of the Fisheries Department, FAO (Fish Resources and Environment Division), and its purpose is to sum up what is known on the state of fish stocks in the Eastern Central Atlantic and to review prospects for development and the more urgent requirements as regards management and research activities. It is part of the Division's programme for the evaluation and surveillance of world fish resources which began in 1971 with publication of the work, "The Fish Resources of the Ocean". Since then, a considerable amount of supplementary data has become available making revision essential. This review has been carried out, region by region, either by a biologist or a small group of specialists having particular knowledge of the resources of the region in question.

The review of information on stocks in the Eastern Central Atlantic has been divided into two parts:

- the first part covers the overall resources of the Gulf of Guinea from Angola to Mauritania, i.e., up to the Northern limit of the extension of tropical stocks. Messrs. T. Boely, F. Domain, P. Fréon, S. Garcia[1/] and F. Lhomme (ORSTOM, France) are the authors of this section;

- the second part, which will be the subject of a separate publication, refers to stocks preferring the temperate zone, which runs from Mauritania up to the Straits of Gibraltar. It is being prepared by Messrs. H. Belvèze (ISPM, Morocco) and G. Bravo de Laguna (IEO, Spain).

In this summary the tunas have been purposely omitted. In view of the widespread geographical distribution of these stocks, they will be dealt with in a separate document on populations in the Atlantic as a whole.

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SUMMARY

This document describes the type, distribution, potential and level of exploitation of pelagic and demersal fish resources in the Eastern Central Atlantic, between Mauritania and Angola.

The most important pelagic stocks are fully exploited, or overexploited, except perhaps for the sardinellas in the Senegal-Mauritania zone.

Prospects for the expansion of demersal fishing in the region as a whole are equally slight. The coastal species are overexploited nearly everywhere and only some species that are currently discarded could enable the total production to be increased. The deep-water stocks, on the other hand, seem to be underutilized even though their potential seems to be less.

The problem of the recent proliferation of trigger fish has also been touched upon.

Finally, research and management priorities have also been defined.

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CHAPTER I

INTRODUCTION

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1. OBJECTIVE

By recognizing the right of coastal countries to control the exploitation of stocks found off their coasts, the law of the sea, which is now being established, has resulted not only in an upheaval regarding conditions of access, and the division of resources, but it also gives coastal States a much wider range of options in the utilization of these resources. Under the old system, in fact, fisheries management was based almost exclusively on biological criteria and objectives which were, in practice, the only ones acceptable to all those taking part in deep-sea fishing which, in principle, was open to everyone. Now the coastal countries have the possibility of utilizing the stocks which come under their control in a way that is much more in their own interests and according to their own capacities. Commercial development and fish management, therefore, can look beyond the mere maintenance of a high level of capture through the application of conservation measures. Steps can now be taken also to reduce the costs resulting from excessive effort or efforts that are not sufficiently efficient, and about the essential question of the division of profit (which can be quite considerable in the case of species with a high commercial value in well managed fisheries) between the various social categories and the national populations as a whole.

This new situation increases the importance of definition and implementation of plans for the development, restructuring and regulation of national fisheries. Such an undertaking must necessarily be based on a complete collection of all the information acquired regarding available resources and, in particular, information regarding the following:

- the type of stocks exploited and capable of being commercially developed,

- a description of their habits as regards distribution and migration. This information is essential in order to draw up agreements between the countries that are interested in exploiting stocks that are present, even seasonally, in sectors that come under different national jurisdictions;

- the evaluation of their size, catch potential and optimum methods for exploitation. Such basic information is needed in order to estimate development prospects as well as management priorities and requirements.

This present summary is an attempt to meet this need.

2. MATERIAL AND METHODS

To carry out this task, all the essential raw material available, as well as those evaluations that have already been published, have all been consulted, collected and compared. Unfortunately, for a variety of reasons (some of which are mentioned below), the basic data available are still insufficient and are not available on a uniform basis. The main reasons for this state of affairs are:

- the fact that local fishery research work is a recent development and in most cases it is still of rather modest proportions;

- lack of continuity in the research carried out by foreign research teams;

- a generalized lack of human and material resources;

- various obstacles of an operational and theoretical nature encountered in the sampling of artisanal fisheries due to the dispersed, varied and eclectic nature of such activity, as is also the case for foreign, ocean-going fleets with their mobility and the related difficulties of communication (Ansa-Emmim and Levi, 1975),

- the multispecies character of tropical stocks, particularly demersal fish, etc.

The fact that information is insufficient and badly distributed can be illustrated by the fact that the stocks in the Gulf of Guinea (due allowance being made for their size) have been the subject of quite thorough investigations as compared to those stocks found in neighbouring zones which are otherwise even richer.

The result of this state of affairs is that evaluations with analytical models are the exception. But they are still of very great interest since this type of evaluation allows us to examine the peculiarities of the dynamics and the productivity of tropical fish populations that are still not very well known. Evaluations by global production models are considerably more common, but the lack of precision in numerous series of cpue and other available indices of abundance, as well as the frequently crude breakdown of catch statistics by fishing zones, means that the potential of numerous stocks or geographical sectors still have to be quantified.

To calculate the probable productivity of these various stocks and fishing zones recourse has also been made to estimates of absolute biomass gained from trawl surveys (demersal fish) or by quantitative acoustic surveys (pelagic species). The estimates of catch potentials which can be deduced in this way cannot, however, be very precise. The absence of any estimates on the principal parameters of the population dynamics (which is nearly total for those stocks whose state still has to be evaluated) means that recourse has to be made to simplified formulae that are very approximative indeed. On the other hand, the use of the latter calls for a knowledge, at least approximative, of the current rate of exploitation in the areas where the prospecting voyages have taken place, and this is a condition that it is not always easy to meet.

Finally, when, for lack of data, none of these methods could be used, an attempt was made to extrapolate to wider geographical sectors the production indices already obtained by the preceding methods. This procedure, by analogy, was mostly used for demersal stocks for whom the densities and the areas respectively occupied by, (a) the reference stocks and (b) the group for which the potential had to be evaluated, were considered capable of supplying extrapolation factors that could be reasonably accurate. However, as in the preceding method, a wrong appreciation of the rates of exploitation of the various stocks gathered together in the same group, is liable to entail a bias that is all the more appreciable when their respective levels of exploitation is different. Moreover, to limit as far as possible the sources of bias related to differences in productivity between stocks and regions, an effort was also being made to restrict the extrapolations to groups where the fish showed a productivity that was sufficiently close to each other. To define these groups, we therefore bore in mind the knowledge acquired in two areas that are essential for the role they play in the productivity of stocks, i.e.:

- the general hydrography of the region and, in particular, the timing and location of seasonal upwellings as opposed to sectors where a layer of warm water is permanently present at the surface and

- biocenology and, more particularly, the nature and the distribution of the large groups of demersal communities: coastal communities as opposed to deep-water communities, communities on soft bottom as opposed to those on hard bottoms.

It is obvious that this method, as with the preceding one, can only give indications on the richness of the various sectors and the stocks in the region. In spite of their lack of precision and the risk of error to which they are prone, the utility of these results is considerable when we come to evaluating investments and the actions necessary for the full commercial exploitation of available resources including the new research required to check and refine these first indications.

This work of compilation and interpretation has been greatly helped by the works of numerous study groups organized especially by FAO/UNDP Project for the Development of Fishing in the Eastern Central Atlantic during the years 1978 and 1979. During these meetings all the stocks in the region have been, one by one, analysed jointly by the various experts on the stocks in question, including the authors of this summary.

3. HYDROGRAPHIC SUMMARY

The area covered by this work extends from Mauritania in the North down to Angola. These limits are only approximate. In fact, they will differ according to the stocks being considered, as the area of distribution of stocks occupying the two border zones do not have the same northern or southern extensions.

This area is not uniform either in hydrography or in population. From the point of view of hydrography, the characteristic feature (because of its influence on the nature, and the distribution and productivity of the populations) is the existence, on the surface, above the shelf, of a layer of warm tropical water (> 24°C) that usually has a low salinity, and which can reach a thickness of 30 to 40 metres. This layer rests on Southern Central Atlantic water that is cold and of low salinity at the levels we are interested in, through the intermediary of a transition zone (thermocline and halocline).

The latitudinal extension of this superficial warm layer is less than the area covered by this study. At the northern and southern limits of the extension of the warm layer, the thermocline rises towards the surface to form two frontal zones, characterized by a contraction of the surface isotherms (23° to 27°C). The layer would seem, furthermore, to disappear seasonally from the centre of the area which it covers off the coast of Ghana and Ivory Coast.

Along with the appearance of seasonal upwellings, during which the colder water that lies just beneath comes up to replace the warm layer on the surface over the shelf, the vertical and horizontal frontiers (the fronts and thermocline, respectively) are subject to seasonal movements which manifest themselves, locally, by oscillations in the thickness of this superficial warm layer (including its temporary disappearance) and, in its extension, by shifts in position all along the coast of the northern front and the southern front and the upwellings which follow them in the direction of the poles (upwelling associated with the Canary Islands current system and upwellings associated with the Benguela current system).

These seasonal variations condition the whole hydro-climatology of the region. Berrit (1973) has described its dynamics and chronology and he reports that twice a year, at what are called the transition periods, the clusters of isotherms move and then settle for periods that may be up to six months, in positions that only vary slightly from one year to the next. The areas swept by the passage of these fronts are called *alternation zones*. One of these, to the North, extends from Cape Verga (Guinea) to Cap Blanc (Mauritania). Its southern counterpart covers the area which runs between Cape Lopez (Gabon) to Cape Frio (Angola). The positions of the fronts would seem to be related, at least indirectly, to the movements of the inter-tropical front and the strengthening of the trade winds. During the northern winter, the northern front is around Cape Verga; the southern front around Cape Frio (Fig.1). Six months later, during the southern winter, these two frontal zones are shifted, the first up to Cap Blanc, the second as far as Cape Lopez (Fig. 2).

During this period when the southern trade wind crossing the Equator changes into the southwest monsoon, the shape of the coast, from Cape Palmas to the mouth of the Niger offers favourable conditions for the appearance of upwellings (Ivory Coast, Ghana). These upwellings cause two supplementary fronts, one is very definite at Cape Palmas and the other more diffused around 2°N between Cotonou and Lomé.

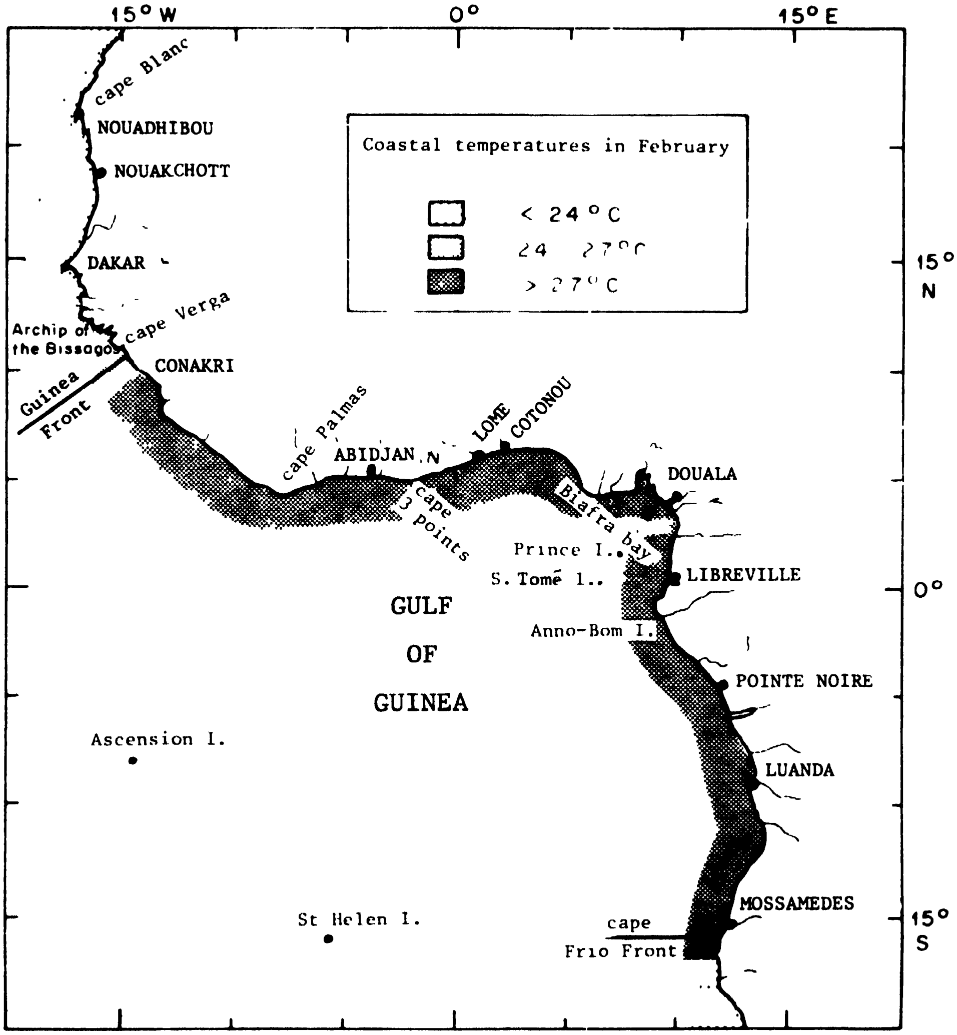

Fig. 1 - Location of the superficial layer and upwelling zones (surface $T^{o} < 24^{o}C$) during the Northern winter

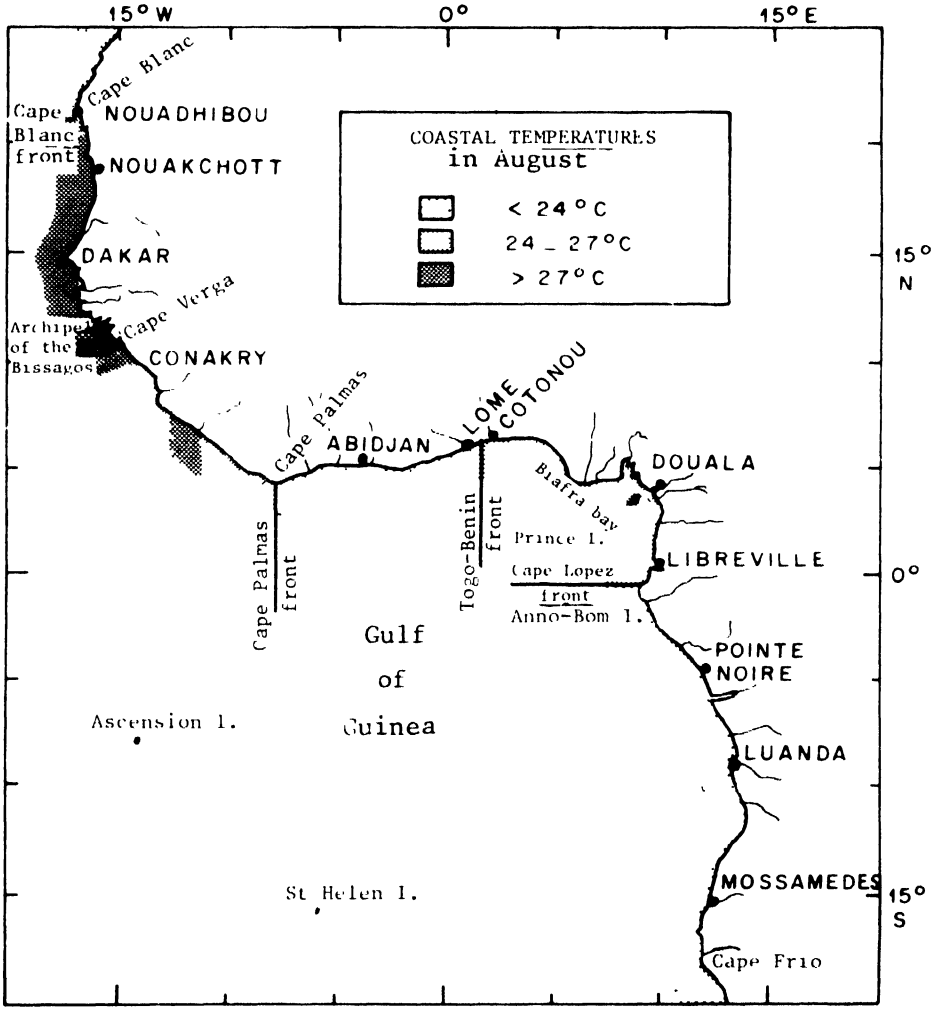

Figure 2 - Location of the superficial layer and upwelling zones (surface $T^{o} > 24^{o}$ C) during the Northern summer

The appearance or the movement of the fronts (and the thermocline) determine two main types of hydroclimatic zones that are either uniform or varied. The varied type is found in the alternation zones and in the upwelling zones; temperature and other characteristics (salinity, nutrient salts, productivity, etc.) vary greatly throughout the year; thermal differences can be more than 12°C. The haline variation sometimes reaches 5% on the surface. In the uniform type, which are found in permanent zones, the temperature, which is always high, varies little throughout the year (about 4°C), while the salinity remains rather low in connexion with the heavy rainfall. This type of hydroclimate is found all along the Grain Coast and the Bight of Biafra.

With regard to the primary and secondary productivities, the dynamics of the frontal structures and the thermocline contribute to the existence of reserve zones which are exceptionally rich. The values put forward by various authors frequently differ from each other and they are not always comparable because of difference in the methodologies employed. Essentially, there are two rich zones that correspond (to the North of Cape Verga and to the South of Cape Lopez) to the shifting areas of the northern and southern sub-tropical fronts. These two areas enclose the considerably poorer Gulf of Guinea that is enriched seasonally by local upwellings in the Ghana-Ivory Coast sector. The areas with permanent warm waters such as the Grain Coast (southern Sierra Leone and Liberia) and the Bight of Biafra (Nigeria), Cameroon, Equatorial Guinea and Northern Gabon) are poor areas although, due to the lack of suitable data, the fertilizing role of terrigenous deposits in the coastal strip still has to be fully appreciated.

4. GENERAL CHARACTERISTICS OF RESOURCES AND FISHERIES

The fish productivity of the area is, therefore, far from being everywhere so low, and so stable throughout the year, as could, a priori, be suggested by the classical patterns of the ecology of tropical regions. The preceding information shows that over the continental shelf, where resources are concentrated, seasonal variations in the environment can reach, in the sectors which benefit from seasonal upwelling, a degree that is quite comparable (>12°C for example) to those found in temperate zones. These hydroclimatic variations can even be quite brusque at the time of the passage of a front or the thermocline with the new seasons coming in very quickly and all of a sudden. These variations are reflected by changes in the specific composition of catches; in the abundance of the various species and in their capturability, which will be more or less greater depending on the upwelling. They also bring about movements of stocks parallel to the coasts that are only small in the Gulf of Guinea itself but which are quite considerable where the fronts sweep the coast over long distances, i.e., in the Senegal-Mauritania sector and in the Congolese-Angolan sector, which is its counterpart. On the other hand, the permanent sectors (Grain Coast and Bight of Biafra) which do not benefit from seasonal upwellings, have an ecology that is typical of tropical regions: slight seasonal variations in the hydroclimate, moderate productivity, and the movements of the stocks are not very great, etc.

The essential role of the fronts, mentioned by Berrit (1961, 1962, 1962a) on the nature, distribution and productivity of the fauna, was noticed very early on by Postel (1968) who identified Cape Verga, Cape Palmas and Cape St. Paul (around 2°E) as the important biogeographic limits. The sector covered by the superficial warm layer, in fact, corresponds to an area with a fauna that is tropical in nature, particularly in the coastal strip. In the Gulf of Guinea that is covered, at least seasonally, by the superficial warm layer, we can, in fact, notice the following (Fager and Longhurst, 1968; Longhurst, 1969):

- a group of coastal populations (0-50 m) that inhabit the warm superficial layer in the permanent warm water sectors and the shifting layer of the thermocline in the alternation sectors;

- a group of deep-water communities that succeed the first in depth.

The coastal tropical fauna is gradually replaced by fauna of a sub-tropical or northern and southern temperature type as we approach, in the direction of the Poles, the extreme limits of the alternation zones associated with the northern and southern sub-tropical fronts.

The multispecies nature of the tropical populations is another essential trait of the stocks and fisheries in the region. The complex mosaic of species, and even populations, that go into the compositon of the ecosystems, and that are simultaneously exploited by the same fleets, offer the fishermen a variety of targets and options. The great scope that is available to them, at least theoretically, as regards the distribution of their activities over various species that are all equally accessible, makes it practically impossible to estimate the actual effort exercised on each species taken individually. Moreover, the large number of species to be estimated makes the analytical approach, species by species, particularly costly in view of the poor research facilities that are currently available. Furthermore, the effects of changes in the schemes of exploitation of the constituent species (because of inter-species relationships) on the specific composition and overall productivity of the ecosystem are now beginning to be discerned qualitatively. The impossibility of gathering the detailed and precise data that are needed (particularly on the actual effort exercised on each of the main constituent species) has meant that, up to now, the problem can only be approached in an empirical fashion. It is nonetheless essential for all that, both for assessments as for management, to the extent that one can expect to increase the fish productivity of the ecosystems by modifying the pattern of the distribution of nominal effort over the basic species. The problem really arises for demersal stocks whose multispecific character is much more marked. It is very likely more marked for hard-bottom populations, where a smaller number of target species are found in different quantities, depending on depth and the season, than for populations on sandy bottoms that are usually more homogeneous in character.

Another consequence of the location of upwelling phenomena in the two sectors adjacent to the Gulf of Guinea is the bipolar distribution of the abundance of fishery resources in the area being studied (see, for example, Figure 2, Chapter III, concerning demersal resources). Whether we look at pelagic or demersal resources we can see that the northern sub-tropical zones (20°-10°N) and southern sub-tropical zones (0°-17°S) are much richer than the Gulf of Guinea itself. This bipolarity in the distribution of resources is more marked to the North with regard to demersal fish, due to the wide extension of the continental shelf which extends over 100 miles in the zone of the Bissagos Islands, while everywhere else its breadth is between 10 and 30 miles approximately.

The same climatic factors (location of the trade winds in relation to the tropical zones with heavy rainfall) are at the basis of the diametrically opposed distribution of resources and human population and, as a result, of markets. The more dense human populations are found along the edge of the Gulf of Guinea while the bottoms that are richest in fish are situated along the desert coasts of the African continent (Mauritania, South Angola/Namibia). This lack of synchronization between areas with a big production and those with a high consumption has conditioned the evolution of the whole plan of exploitation and utilization of resources in the region (Gulland *et al.*, 1973). The areas where demand is high, with the highest population, in the centre, have been quickly exploited, sometimes excessively, and the last few years has seen the setting-up of a commercial network (with a chain of cold storage and ice facilities) that allows for the distribution of fish to the interior of coastal countries. Simultaneously, several of the latter have had to call more and more on imports to meet their own production deficits. Whereas, originally, almost the entire production of the richer areas went to the industrialized countries, there is now a trend toward the development of a trade in the species of large consumption between the regions with excessive production in orthern and South estern Africa, and the countries of the Gulf of Guinea.

Of course, it has been the richer sectors which have attracted most of the interest of the foreign fleets coming from all parts of the world: eastern Europe, the Mediterranean, the Far East, North America, Central and South America, and including (albeit on a rather modest scale), some countries in the Gulf of Guinea itself - Ghana, Ivory Coast, for example (Gulland *et al., op.cit.*). These areas and these fleets have been at the origin of the astonishing takeoff in production in the CECAF region which in 20 years has soared to reach 3.8 million tons in 1977. And it is also here, where this explosion in production and foreign participation has been most marked, that the desire of the coastal countries to control the exploitation of their resources has also most clearly emerged. The measures that have been taken have already brought about quite appreciable changes in the volume, as well as in the distribution, of the activity of these fishing fleets. These changes in the system of exploiting stocks have complicated the work of assessment: all the more so in that fishing statistics, in general, are of rather poor quality.

Industrial fishing is not the only important production sector. Artisanal fishing is highly developed in certain countries, such as Senegal or Ghana. In Senegal, for example, artisanal fishing accounts for 120 000 tons per year, which represents two thirds of the national production. The social role of this activity is obviously much more important than the purely economic aspect and this holds true for all the coastal countries. This type of fishing is, generally speaking, not well known and its expansion depends on a better appreciation of its advantages as well as its constraints. Wherever it has developed, the current lack of knowledge of this activity, particularly as regards volume of catches and their composition (species, sizes) constitutes a major handicap in the assessment of West African stocks.

The lack of geographical synchronization between resources and populations; the rapid and poorly controlled development of the main industrial fisheries; the importance of a scarcely known artisanal fishery; the great variety of environmental conditions with their biological repercussions; as well as the multispecies nature of the fish populations, are all at the basis of the difficulties that have most seriously hindered the progress of research into the fisheries potential of the West African inter-tropical zone. This situation has been aggravated by a lack of human and material resources for regional research work. Only the Congo, Ivory Coast, Ghana, Mauritania, Nigeria, Senegal and Sierra Leone have a small fisheries research infrastructure available that is frequently insufficient and whose field of activity is nearly always just local. This unfavourable situation determined the approach that has been adopted in this work for the assessment of resources. It has seemed logical to treat demersal and pelagic resources separately.

In the case of the former, the existence of a relatively restricted number of important species representing considerable biomasses has led to the carrying-out of assessments on stocks of single, or relatively few, species and to the subsequent grouping of the results by large ecological or statistical divisions.

In the case of the latter, the existence of a large number of species and the frequently poor quality of the statistics available (imprecise locations for the origin of capture, mixing together of similar species, variations over a period of time in the practices for discarding certain fish, etc.) have meant that an analytical approach, species by species, could not be taken. The few specific assessments that have already been done have simply been mentioned. In spite of the real danger of creating a mixture, the assessments that one can get either with the help of global production models based on the totality of species caught simultaneously by the same fleet, or from assessments of overall biomass obtained by prospecting, have been extrapolated overall to wider geographical groupings, particularly to the statistical divisions of CECAF.

Prawn stocks (*Penaeus duorarum*), which are well defined geographically, are examined separately as they are the subject of a specialized fishery, practically monospecific, by fleets that are locally based or that are part of a specialized artisanal fishery. In these conditions, it has frequently been possible to collect statistics that were often sufficiently precise to permit detailed assessments.

Tuna fish resources have not been included in this summary. In view of their wide distribution, they will be the subject of a separate analysis based on the Atlantic Ocean as a whole, but always within the framework of the regional summaries on the nature and state of resources prepared by the Fisheries Department at FAO.

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CHAPTER II

COASTAL PELAGIC RESOURCES

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ATTACHMENTS 4 AND 5

ATTACHMENTS 6 AND 7

In the CECAF region, the fishery for coastal pelagic fish has especially developed over the past fifteen years to the extent that this category of species now represents the majority of the catches made from South of Morocco to the Congo River. From Mauritania to Angola nine species - mostly clupeids and carangids - are of particular interest because of their economic importance. The round and the flat sardinellas *(Sardinella aurita* and *S. maderensis)*, the bonga *(Ethmalosa fimbriata)*, the cunene horse mackerel *(Trachurus trecae)* and yellow horse mackerel *(Caranx rhonchus)*, the Spanish mackerel *(Scomber japonicus)* are found throughout the area. Three other species, typical of temperate zone, are found only in the northern part of the region: the blue fish *(Pomatomus saltator)*, the Atlantic horse mackerel *(Trachurus trachurus)* - both of which are caught from Morocco to Senegal - and the sardine *(Sardina pilchardus)* that is fished from Europe to the coasts of Mauritania.

A first inventory of West African fish resources was carried out on the occasion of the simposia at Abidjan in 1966 (Unesco/FAO/OAU, 1969) and Tenerife in 1968 (Letaconnoux and Went, 1970). Subsequently, Longhurst (1971) attempted an assessment of the clupeid resources in the region, and then Gulland (1971) looked at the number of species as a whole. More extensive statistical data, a better knowledge of the biology of the species, and recent surveys made possible by the perfecting of acoustical techniques, have brought new information, the most important of which is contained in the following documents:

- the publications of the FAO Fishery Committee for the Eastern Central Atlantic (CECAF): the reports from these working groups on the assessment of resources and the statistical bulletins,

- the publications of the research centres at Abidjan (Ivory Coast), Dakar (Senegal), Freetown (Sierra Leone), Lagos (Nigeria), Nouadhibou (Mauritania), Pointe-Noire (Congo) and Tema (Ghana), and works by Norwegian, Polish and Soviet researchers,

- the acoustical survey campaigns carried out by the various oceanographic ships, particularly by the R/V THUE Jr. (FAO), G.O. SARS (Norway) and CAPRICORNE (France).

1. DISTRIBUTION OF RESOURCES AND A BRIEF REVIEW OF THE BIOLOGY OF THE SPECIES EXPLOITED

From Mauritania (26°N) to the River Congo (6°S), the size of the catch in pelagic fish has grown six times in eleven years, going from 260 000 tons in 1966 to 1 700 000 tons in 1976 (Fig. 1, Attachment 1). The biggest expansion was between 1968 and 1970 mostly in the sub-tropical northern zone, i.e., from Cape Bojador (26°N) to Guinea (9°N) where the catches have practically gone up ten-fold from 1966 to 1976 (Fig. 1, Attachment 2). This increase has been in the catches of carangids (x 9) and even more in the clupeids (x 20). On the other hand, in the Gulf of Guinea proper, i.e., from Sierra Leone (9°N) to the Congo River (6°S), supplies have only doubled during the same period, going from 110 000 tons in 1966 to 230 000 tons in 1976 (Fig. 1). The clupeids represent almost the entire catch (Attachments 3-5). Although this sector is more spread out than the preceding one, it supplies (since 1969) less than 20% of the total catch for the geographical sector being studied here.

1.1 Clupeids

1.1.1 The European pilchard *(Sardina pilchardus)*

The pilchard is a species typical of temperate zones that is found in abundance in Morocco but does not seem to extend, at least in commercial concentrations, below Cape Bojador (26°N). However, the existence of a "dwarf type" off the coast of Cap Blanc (21°N) has been suggested by Cadenat and Moal (1955). Starting from 1970, this species is found in growing quantities (Table 1) in the catches of trawlers and then seiners all along the Mauritanian coast between 26°N and 19°N, the southern limit at the Arguin Bank.

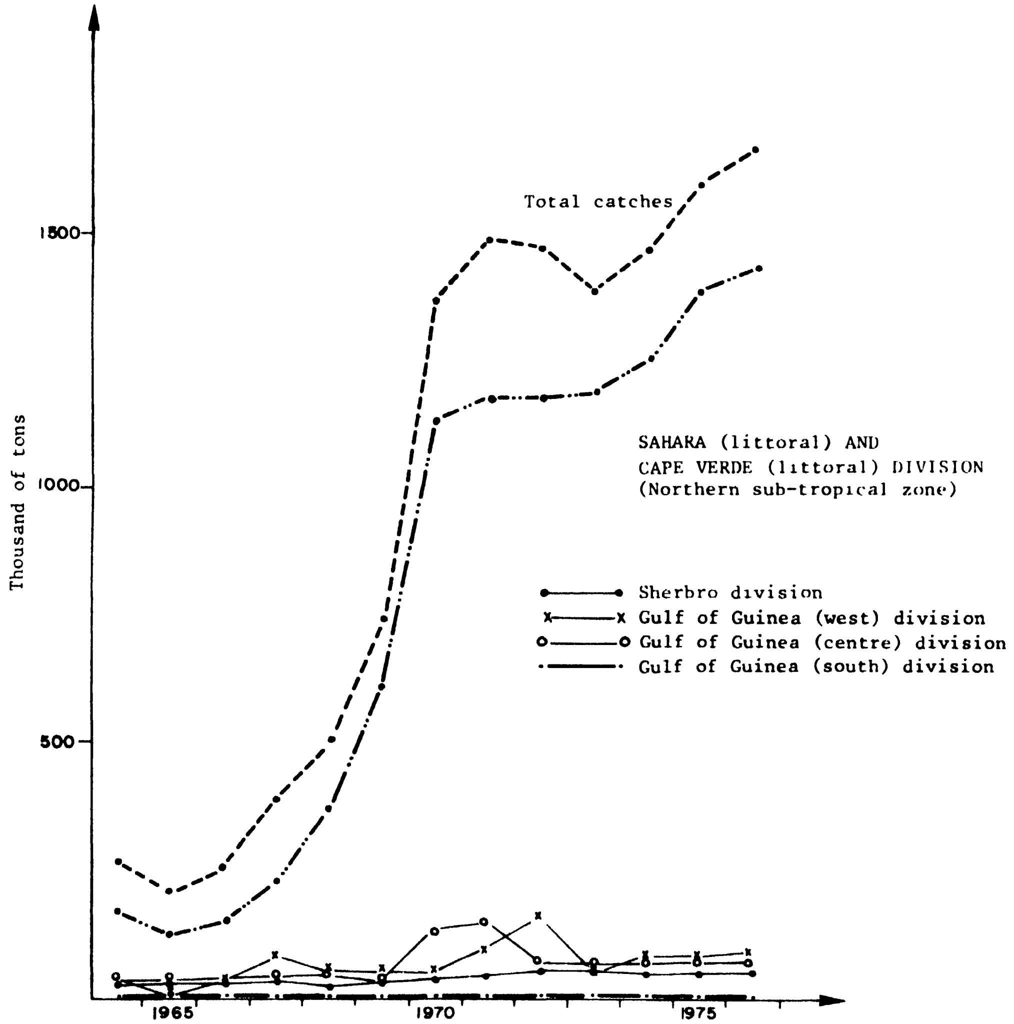


Figure 1 - Annual production of coastal pelagic fish by statistical divisions between Mauritania and the Congo.

Table 1 - European pilchard *(Sardina pilchardus)* in the Mauritanean sector (26°N to 19°N): catches, efforts and cpue

		1969	1970	1971	1972	1973	1974	1975	1976
Catch ('000 of tons)	USSR[1]	80.1	88.7	123.6	91.0	154.8	287.2	357.2	515.0
	Poland	0	0.005	0,3	3.1	14.5	19.8	69.6	100.3
	Other countries	0	0	0	1.2	23.1	67.5	49.9	38.2
	TOTAL	80.1	88.705	123.9	95.3	192.4	374.5	476.7	653.5
Polish effort[2]		1310	861	1175	873	1237	1088	2818	3586
Polish cpue (t/24 h)		0	0.006	0.3	3.5	11.9	18.2	24.7	28.0

1/ It is likely that a part of the Soviet pilchard catch is taken North of 26°N

2/ Fishing effort in fishing days (24) normalized for a B 23 trawler

Sources:
- USSR and Poland: data communicated to the special CECAF working group on West African coastal pelagic fish from Mauritania to Liberia (Dakar, Senegal, June 1978) (FAO, 1979)
- FAO (1979a)

The pilchard appeared in the catches several years after fishing had developed in the region. It does not seem that the growth in the catch of pilchards can be set down to an extension southward of the activity of the fishing fleets. In fact, the increase in catches and yields is seen in the Polish statistics (which always carefully distinguish between the different species) relating to the Mauritanian sector alone (Table 1): Fishing operations would seem to have long preceded the growth in pilchard catches. With the generally colder conditions that have been registered in the area since 1970, this species could have gradually moved South, finding favourable conditions for development along the Mauritanian coasts (Maigret, 1974; Domanevski and Barkova, 1978; Fréon and Stéquert, 1978). For Krzeptowski (1978), the stock that is found off the Mauritanian coast is isolated from the pilchard stocks found to the North of Cape Bojador. Since 1974, the pilchard has been reported in Senegal, in the Bay of Goree, where tuna fishing boats and beach seiners have captured several tons toward the end of the cold season. Catches have even been reported further South off Sierra Leone.

1.1.2 The round sardinella

The round sardinella is found all along the African coast, from the Mediterranean to Cape Frio (18°S). It lives on the continental shelf and prefers saline waters (35°/oo) that are clear with a minimum temperature of less than 24°C. The round sardinella, in fact, is only really abundant in three sectors of the Eastern Central Atlantic that are characterized by the seasonal appearance of important cold water upwellings (Fig. 2), that is to say:

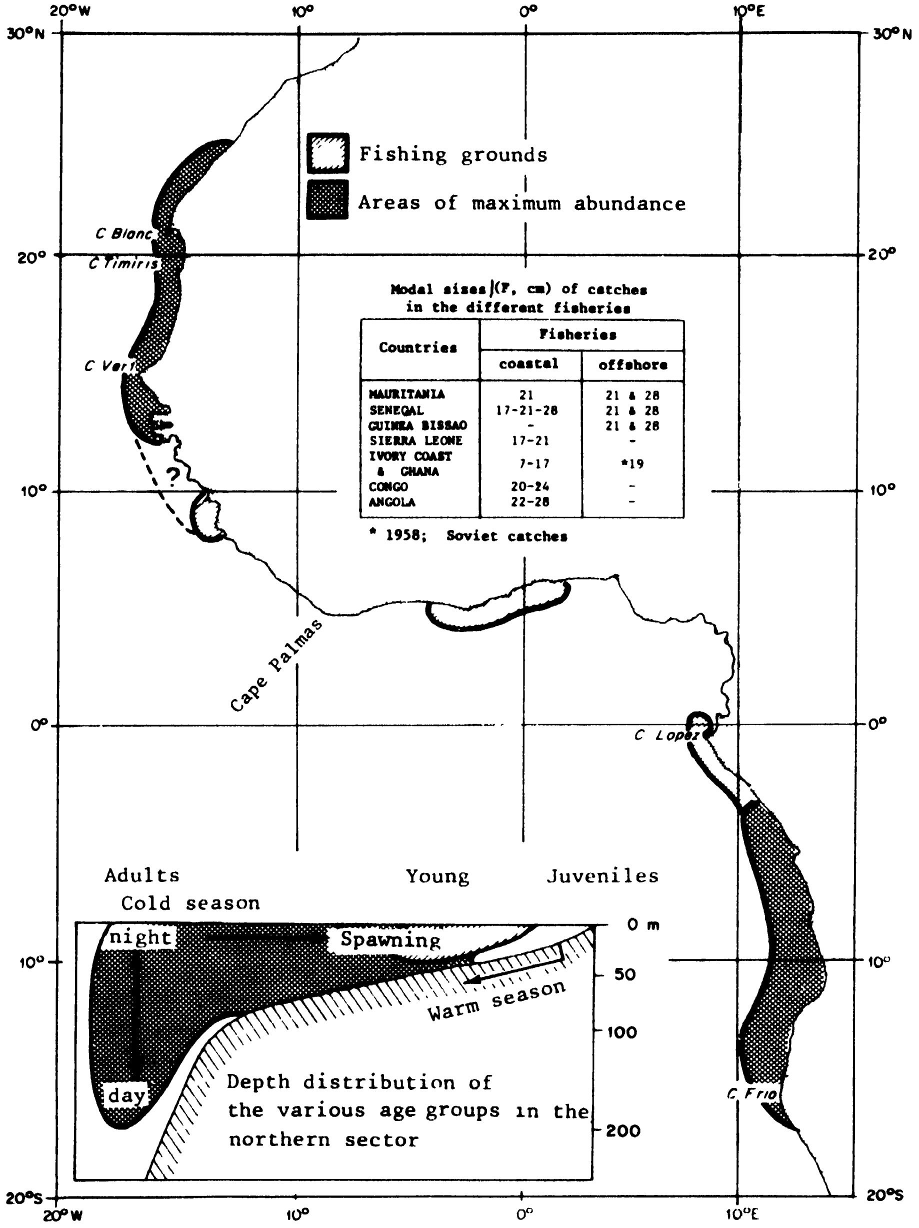
- from Mauritania (26°N) to Guinea (10°N), i.e., in the CECAF Sahara (littoral) and Cape Verde (littoral) divisions;
- off the Ivory Coast and Ghana, i.e., in the Gulf of Guinea (West) division;
- from the South of Gabon 0°) to the South of Angola (17°S), i.e. in the Gulf of Guinea (South) division and off Angola.

No important concentration nor any appreciable fishery have been reported in the intervening zones. Each of these three big areas of concentration is quite certainly occupied by distinct populations, as the system of currents is not favourable to any exchanges between them (FAO, 1973).

In each of these three sectors, we find mature females as well as larvae in the plankton throughout practically the entire year, but there are several maximum points of reproduction. Spawning takes place at average depths of the continental shelf and the larvae then drift to the coast on the superficial layer. This general system is, however, strongly influenced by the particular conditions at the different sectors where it takes place. These, therefore, will be examined separately.

1.1.2.1 Northern sub-tropical zone: Sahara (littoral) and Cape Verde (littoral) divisions

In this sector, the most important breeding period begins South of Dakar in May, carries on into June over all the Senegalese coast and then northward up to Cape Timiris (19°N) to conclude in July-August off the coast of Mauritania. Spawning seems to take place between 30 and 50 metres depth. The larvae carried North and toward the coast by the surface currents grow rapidly and reach three centimetres in a month (Conand, 1977). They collect in vast nurseries located, in particular, between Gambia and the Cape Verde Peninsula, along the Mauritanian coast between 17° and 18°N, inside the Arguin Bank and in the Bay of Lévrier. A second reproductive cycle, in which only the young are involved, has been noted in October-November off the Senegalese coast. This spawning is coastal and its volume varies greatly from one year to the next. From January to March there are more spawnings on the edge of the continental shelf, but their importance is slight and it is uncertain what becomes of the larvae that are then carried South and into the open sea (Conand, 1977; Boely *et al*, 1978).



Modal sizes (F, cm) of catches in the different fisheries

Countries	Fisheries	
	coastal	offshore
MAURITANIA	21	21 & 28
SENEGAL	17-21-28	21 & 28
GUINEA BISSAO	-	21 & 28
SIERRA LEONE	17-21	-
IVORY COAST & GHANA	7-17	*19
CONGO	20-24	-
ANGOLA	22-28	-

* 1958; Soviet catches

Figure 2 - Round Sardinellas (*Sardinella aurita*). Main zones of abundance and fishery, main size classes in the various fisheries and depth distribution of the different stratas of population in the northern sector (adapted from FAO, 1971)

In this zone, the round sardinella reaches a maximum size of 32 centimetres. Growth is rapid (Boely *et al.*, in press). Adults of between 25 and 32 centimetres in size move seasonally along the coasts between Mauritania and the Bissagos Islands. They get to Senegalese waters in December-January and they then concentrate along the edges of the shelf between the Cape Verde Peninsula and Guinea Bissau and remain there until April. Starting in May, with the warming-up of the surface waters, they colonize the continental shelf and by starting to breed they initiate their movement northward (Fig. 3). At the end of their first year, the young join them in carrying out their first reproduction cycle. In July, these fish reach the Arguin Bank and remain there until October-November between 20°N and Cape Barbas. With the reestablishment of the upwelling, they start a new migration toward the South (Boely *et al.*, 1978). Table 2 shows the main zones of concentration of round sardinellas in the Senegalese-Mauritanian sector and the type of fishery that is carried on (taken from Boely (1971), Maigret (1972), Chabanne and Elwertowski (1973), Boely and Ostvedt (1976)).

However, during the entire cold season, deep sea trawlers fish the adult round sardinella North of 20°N (Elwertowski and Boely, 1971). Maigret (1972) has also noted their presence in the catches of big seiners. Although we cannot discard the hypothesis of a distinct population, it is possible that some of the adults do not participate in the winter migration toward the Senegalese coast.

South of the area, off the northern coast of Sierra Leone, concentrations of round sardinellas have been observed from January to May, and these are fished by a few Ivorian seiners and, up until 1970-72, by tuna fishing ships looking for live bait. They seem to leave this sector in May and head North (FAO, 1971). Not much information is available on these concentrations and any connexion between them and the Senegalese-Mauritanian group remains to be demonstrated.

1.1.2.2 Gulf of Guinea (West) division

The migration pattern of the Ghana-Ivory Coast stock (Fig. 4, from Ansa-Emmin, *In* FRU/ORSTOM, 1976), as well as its main biological functions and its fishery, are intimately bound up with the upwelling cycle. During the first half of the year, before the cold water begins to rise up, the adult population winters on the bottoms from 50 to 80 metres between the longitudes of Cape Three Points and Accra. At the beginning of July, when the upwelling starts, the population moves closer to land and the surface and thus becomes accessible to the local fleets, particularly canoes from Ghana. Growth is then very quick. Spawning, which can be noted more or less throughout the year, is then at its maximum. Gradually, as the upwelling season progresses, the stock spreads out off the eastern half of Ivory Coast and, especially, toward the East as far as Togo. At the end of this season, towards the month of October, the area of distribution of this stock begins to contract and in December the population returns to its deep-water bottoms for wintering. Similar displacements, toward the coast and the surface, are also produced with the small upwellings that are observed in January and sometimes later on, but their extent is equally restricted. Regardless of the season considered, these movements are small when compared to those of the populations in the Gulf of Guinea (Figs. 3 and 5). This difference is related to the absence in the Gulf of Guinea (West) division of any large seasonal movements of a thermal front comparable to the intertropical northern and southern fronts.

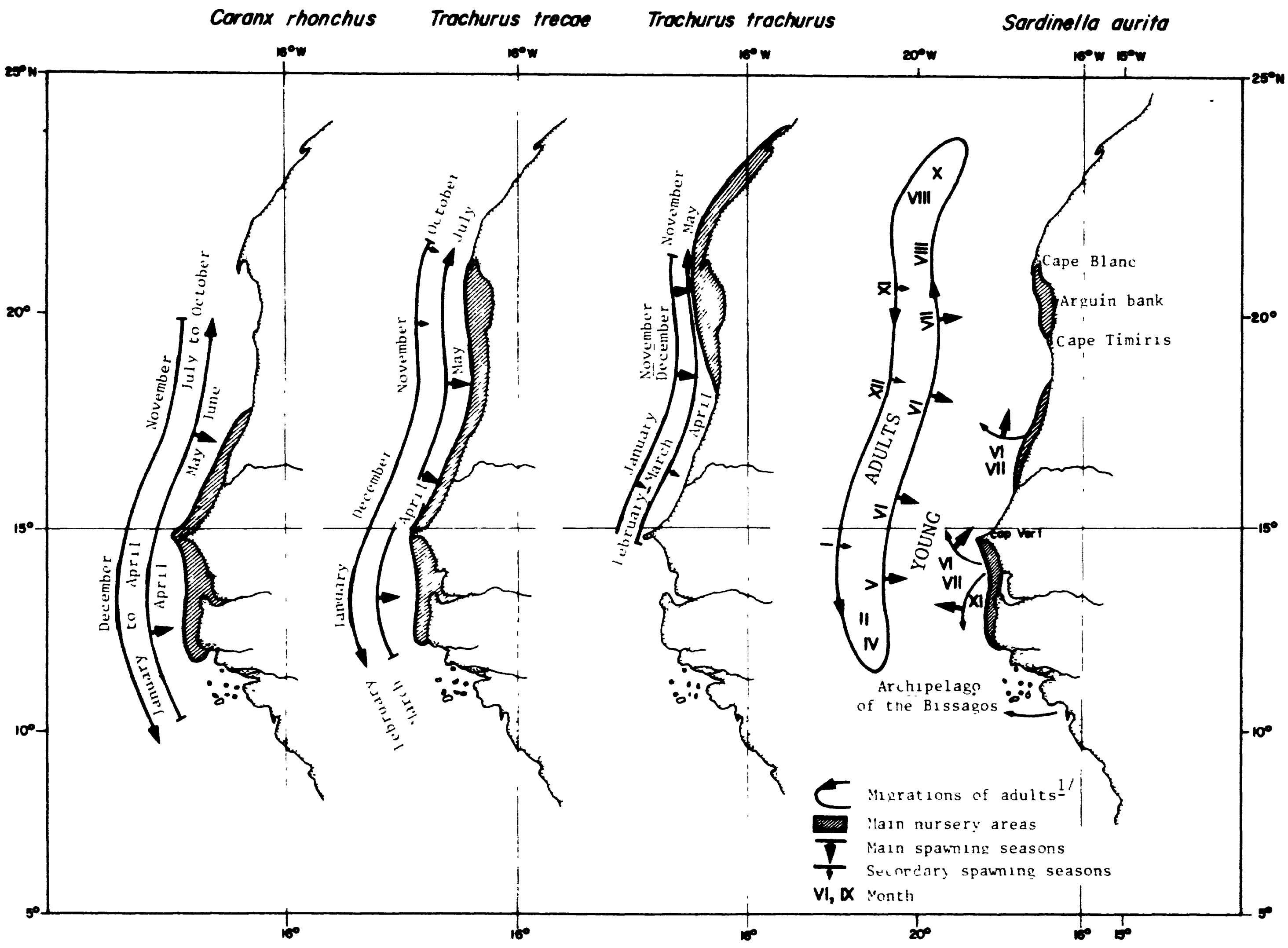


Figure 3 - Jack and Horse mackerels (*Trachurus trecae*, *Trachurus trachurus* and *Caranx rhonchus*) and the round sardinella (*Sardinella aurita*) in the Senegal-Mauritania area: distribution, migration and life cycle.

1/ This migration actually takes place over the continental shelf; for typographical reasons, the perpendicular scale from the coast has not been maintained.

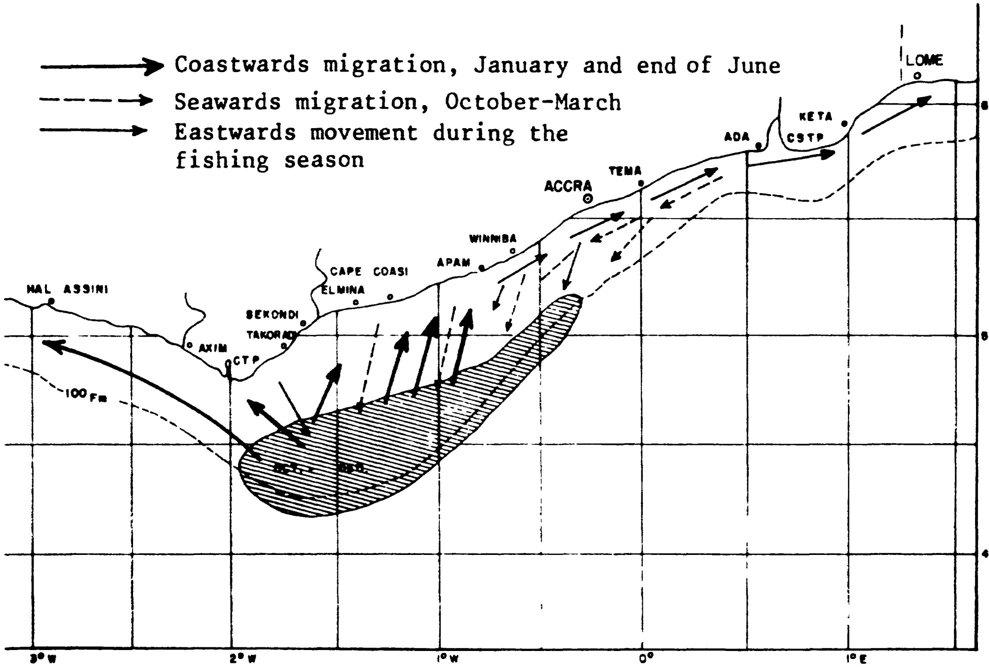

Coastwards migration, January and end of June
Seawards migration, October-March
Eastwards movement during the fishing season
LOME
KETA
CSTP
ADA
TEMA
ACCRA
WINNEBA
APAM
CAPE COAST
ELMINA
SEKONDI
TAKORADI
AXIM
CTP
HAL ASSINI
100 Fm
6°
5°
4°
3° W
2° W
1° W
0°
1° E

Figure 4 - Round Sardinella (*Sardinella aurita*) in the Gulf of Guinea (West) Division. Seasonal distribution and movements (From Ansa-Emmim, 1976, In FRU/ORSTOM, 1976).

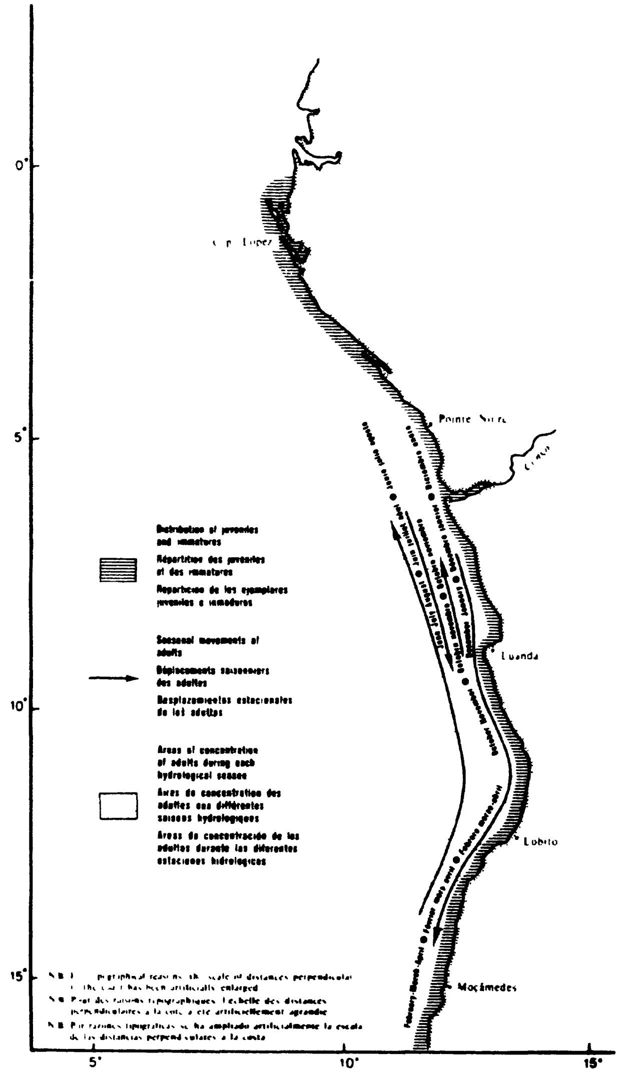

C. Lopez
Pointe Noire
Luanda
Lobito
Moçâmedes
Distribution of juveniles and immatures
Répartition des juveniles et des immatures
Repartición de los ejemplares juveniles e inmaduros
Seasonal movements of adults
Déplacements saisonniers des adultes
Desplazamientos estacionales de los adultos
Areas of concentration of adults during each hydrological season
Aires de concentration des adultes aux différentes saisons hydrologiques
Áreas de concentración de los adultos durante las diferentes estaciones hidrológicas
0°
5°
10°
15°

Figure 5 - Round Sardinella (*Sardinella aurita*) in the southern sub-tropical zone; Seasonal distribution and migration (From Ghéno and de Campos Rosado, 1972, In FAO, 1973a).

Table 2 - Round sardinella *(Sardinella aurita)* in the northern sub-tropical zone: seasons and types of fishery by geographical sectors

Sectors	Soundings (m)	Strata exploited	Known fishing seasons	Known type of exploitation
Guinea-Bissau 11°-12°N	20-50 50-200	young, adults	March-April March-April	Large-scale (seiners)
South Senegal and Gambia 12°-15°N	0-10	juveniles	all year	Beach seine
	10-30	young	March-July Sept.-Jan.	Canoes and local seiners
	50-200	adults	Jan.-April	Local seiners
			Feb.-May	Large-scale (seiners and trawlers)
Northern Senegal 15°-17°N	50-200	adults	May-June	Large-scale (seiners)
	50-200	adults	March-June	Large-scale (trawlers)
South Mauritania 17°-19°N	20-50	young	November	Large-scale (seiners)
	50-200	adults	January June-July	Large-scale (seiners)
			Dec.-April June-July	Large-scale (trawlers)
North Mauritania 19°-24°N	10-30	young	all year	Local seiners
	50-200	adults	June-Dec.	Large-scale (seiners)
			all year	Large-scale (trawlers)

It can also be noted that in this division the maximum size, around 25 cm, is considerably less than the size reached by the Congo-Angolan population and those of Senegal and Mauritania (maximum size of more than 30 cm). Likewise, the size at first maturity (L_{50}) is here only 15 cm while it reaches 21 cm in Congo (Fontana and Pianet, 1973) and 18.5 cm in Senegal.

1.1.2.3 Soutnern sub-tropical zone: Gulf of Guinea (South) division and Angola

This sector shows many similarities with its northern sub-tropical counterpart. From South of Gabon to South of Angola, there seems to be only one stock. The adults move seasonally between these two limits following the oscillations of the southern inter-tropical front (Fig.5). The biology of this species has been studied more in the Congo (Ghéno, 1975). Two major spawning periods have been observed off the coast of this country, the main one from May to September and the other in January, i.e., during the two cold seasons.

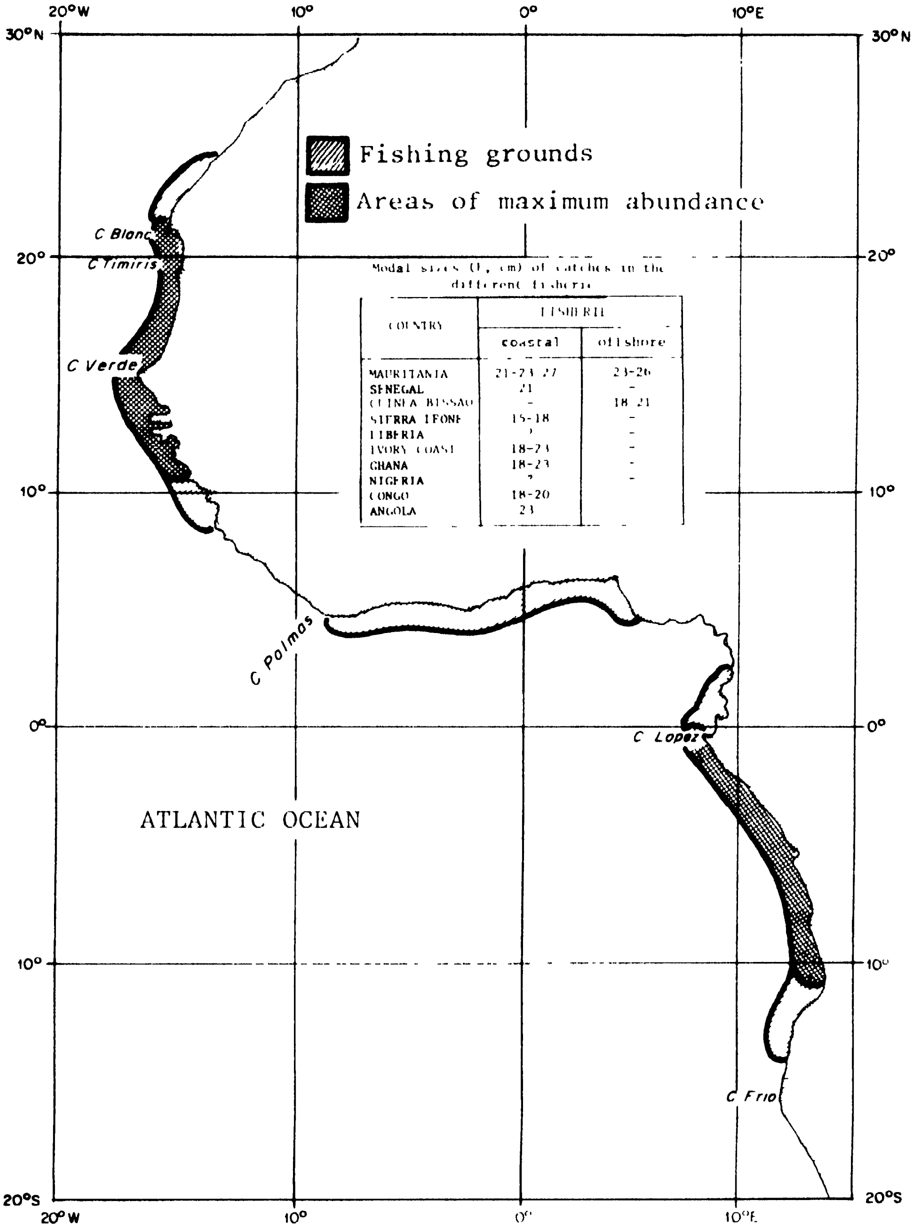
The young apparently colonize the entire coastal strip, from the Bay of Tigers (Angola) up to Cape Lopez (Gabon), (Ghéno and de Campos Rosado, 1972). In particular, an important nursery area has been located between Mayumba (3°30'S) and Cape Lopez (0°30'S). Other equally important ones probably exist along the Angolan coast.

When they are between 10 and 14 cm young fish leave the coastal nurseries and remain for some time in the shallower part of the shelf before rejoining the adult population. It is at this time that the young become vulnerable to the coastal sardine fisheries based at Pointe-Noire (Congo) and in the North of Angola (Luanda and Porto-Amboin). At Pointe-Noire, this recruitment takes place throughout the year with a maximum point from September to January; it supplies most of the catch of round sardinellas. North of Angola (Luanda, Porto-Amboin), the young contribute less than the adults to the catch where they tend to show up mostly in the main cold season (June to August). The adults, aged from 3 years up, migrate seasonally over very large distances (Fig. 5) from the South of Angola up to Congo. This is the reason why they only appear in the Congolese catches in the middle of the cold seasons (July-August and occasionally in January); at Luanda and Porto-Amboin, where they supply the major part of fish catch, they are taken almost throughout the year except for the hot months (January to March) when they are only fished to the South, in the region of Porto Alexandre and the Bay of Tigers (Ghéno and de Campos Rosado, 1972).

Between 1° and 2°S, bait boats fishing for tuna catch small sardinellas (10 to 18 cm) whose biological characteristics seem different from those of the above stock (e.g., 12 cm at first sexual maturity instead of 20 cm). However, it is not known if this is a separate population (Fontana and Pianet, 1973). Furthermore, North of Cape Lopez, Ghéno (1970) has reported the existence of an isolated, small-sized population which would seem to possess distinct biological characteristics.

1.1.3 The flat sardinella *(Sardinella maderensis = S. eba)*

The flat sardinella is found from Mauritania to Angola. Although its ecological necessities are quite different, it has more or less the same area of distribution as the round sardinella. It is more of a coastal fish, more euryhaline, most often found to be abundant near the outlet of water courses. It prefers warmer waters with a temperature above 24°C and seems to avoid waters that are not clear. Nevertheless, like the round sardinella, it is not very abundant in areas without upwelling where the warm and low saline superficial layer is permanently present (The Grain Coast, Bight of Biafra, Fig. 6). While spawning is continuous throughout the year, there is still a maximum reproduction point which is at the beginning of the hot season in Senegal, the hot season in Ivory Coast and the cold season in the Congo. The young fish are concentrated in the coastal waters from where they gradually move off as they grow older; but the stratification toward the open sea with age is never so clear cut as it is for the *Sardinella aurita* (Boely, 1979), and the great majority of the adults remain confined over the shallow half of the continental shelf.



Modal sizes (L, cm) of catches in the different fisheries

COUNTRY	FISHERIES	
	coastal	offshore
MAURITANIA	21-23 27	23-26
SENEGAL	21	-
GUINEA BISSAU	-	18 21
SIERRA LEONE	15-18	-
LIBERIA	?	-
IVORY COAST	18-23	-
GHANA	18-23	-
NIGERIA	?	-
CONGO	18-20	
ANGOLA	23	

Figure 6 - Flat Sardinella (*Sardinella maderensis*). Main areas of abundance and fishing and main size classes in the various fisheries (modified from FAO, 1971).

It is in the southern sub-tropical area (Congo-Angola) that the movements of this species are better known (Fig. 7, Ghéno and de Campos Rosado, 1972). A similar population occupies the coast from Mayumba (3°30'S) to Gabon as far as South of Lobito (13°S) in Angola, with the juveniles spread along the coast throughout the area of distribution. The individuals of between 14 and 20 cm then regroup between Mayumba and the North of Angola. The Congolese fishery mainly concentrates on this section of the stock. Starting from 20 cm, the young move toward the South and join the adults concentrated off Angola. Compared to the round sardinella, the adult flat sardinella are much more sedentary and they only travel limited distances along the coast.

A distinct group, which differs in biological characteristics from the Angolan population, seems to exist along the Gabonese coast (Ghéno, 1970).

In the northern sub-tropical zone, two important nurseries have been located, one from South of Dakar to the Bissagos Islands, the other at the level of the Arguin Bank and South of Cape Timiris. The young breeding animals (16 to 24 cm) move seasonally for very limited distances inside these nurseries. Throughout the year they supply the main part of the catch for the coastal fleets and they also form part of the catch of the long distance fishery seiners when these operate sufficiently close inshore (Boely and Østvedt, 1976). The adults (> 24 cm) are mostly found North of the Cape Verde Peninsula as far as Mauritania. They are captured by the Senegalese artisanal fishery (beach seines and purse seines). They can also be found in the catches of deep sea seiners, but their contribution to the total catch is small. These adults would seem to form a single stock, but their relations with the two nursery areas are still little known (Boely, 1979).

It is in these two regions (Fig. 6), to the South and North of the Gulf of Guinea, that the flat sardinella is most abundant; more of a coastal fish it is less fished than the round sardinella by the deep sea fleets. The species is common from the Ivory Coast to Nigeria where, it seems, there are several small populations that are of great importance for the local fisheries particularly the artisanal type. Thus, on the Ivory Coast, the seiners catch mainly the adults and the young breeding fish of this species, while in Ghana the beach seine fishery bears mainly on the juveniles.

1.1.4 The small sardinella *(Sardinella (= Harengula) rouxi)*

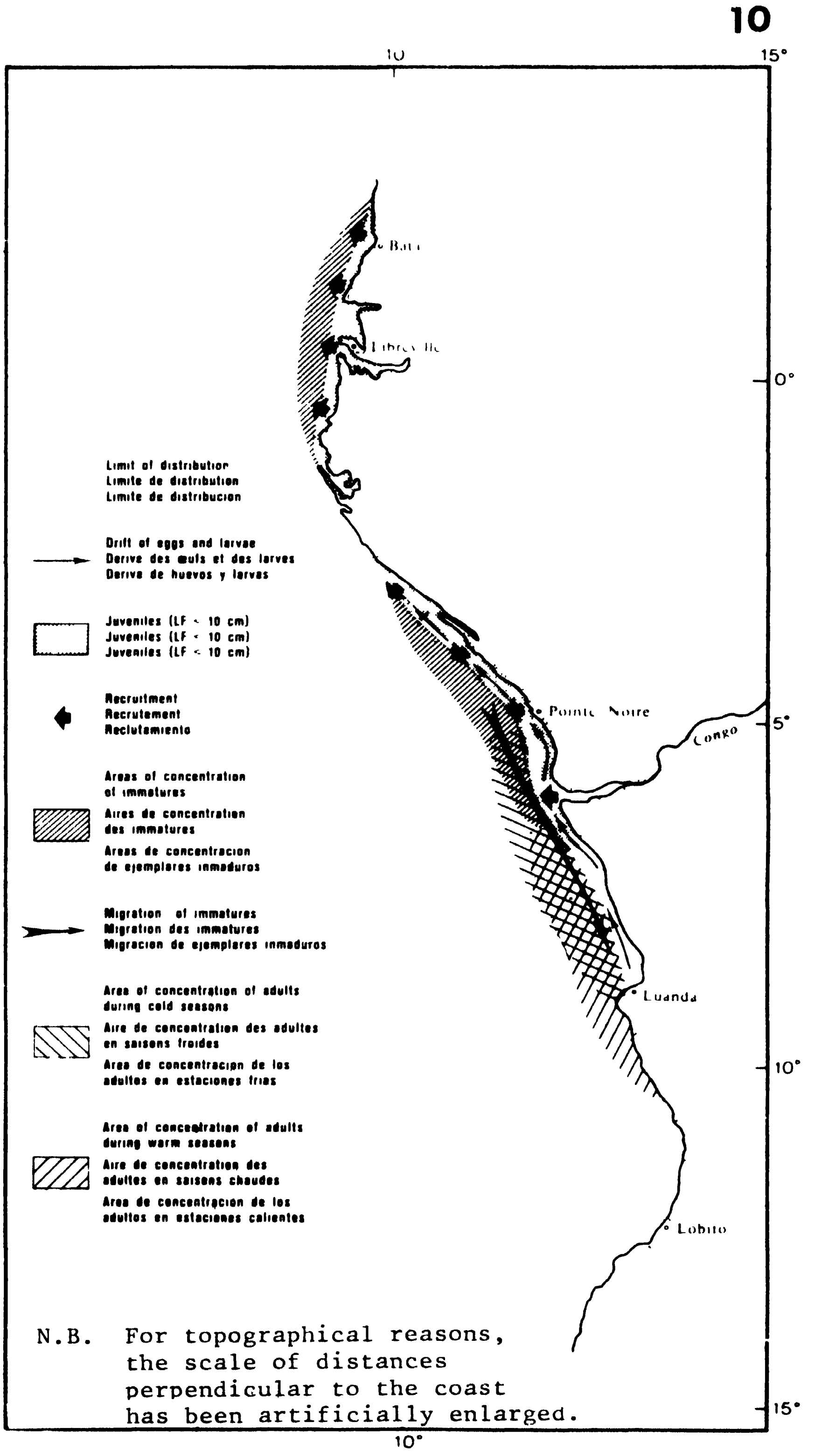
This small sized clupeid is never distinguished from the flat sardinella in the statistics for landings. Its biology is not well known. Maximum length and size at first capture are clearly inferior to those of the flat sardinella. The construction of its less tight gill suggests a different diet (fish larvae, large zooplankton, etc.). This coastal species is found near the bottom down to around -70 metres where it is sometimes caught by trawling (Marchal, personal communication).

According to Krzelj (1971), the larvae are distinguished from other sardinellas over 9.5 mm length.

1.1.5 Bonga *(Ethmalosa fimbriata)*

In order of importance, the bonga is the third clupeid of the Gulf of Guinea. This is an even more coastal species that rarely goes below 20 metres. It is even more euryhaline than the flat sardinella, and it is found in estuaries, in the sea or lagoons, and in places that are liable to have great variations in salinity. It prefers warm and cloudy waters. Because of these ecological preferences, it tends to replace the flat sardinella, and even more clearly the round sardinella, in those sectors without upwelling with strong surface desalination, (Sherbro and Gulf of Guinea (centre) divisions respectively (Fig. 2 and 6)). Its biology and migrations seem small in extent and limited to estuaries and the adjacent coastal areas (Longhurst, 1960).

In Senegal the bonga grows to a size of 35 cm. It can be caught up to 200 km inland (the Senegal and Gambia rivers) in areas that come under the influence of the influx of saline water. The species breeds all year both in the sea and estuaries and rivers. Spawning, however, has two low points, one in the cold season and the other during the summer flooding of the rivers. Juveniles are definitely more abundant in rivers and in estuaries, while


10
10
15°
0°
5°
10°
15°
10°
Bata
Libreville
Pointe Noire
Congo
Luanda
Lobito
Limit of distribution
Limite de distribution
Limite de distribucion
Drift of eggs and larvae
Derive des œufs et des larves
Deriva de huevos y larvas
Juveniles (LF < 10 cm)
Juveniles (LF < 10 cm)
Juveniles (LF < 10 cm)
Recruitment
Recrutement
Reclutamiento
Areas of concentration of immatures
Aires de concentration des immatures
Areas de concentracion de ejemplares inmaduros
Migration of immatures
Migration des immatures
Migracion de ejemplares inmaduros
Area of concentration of adults during cold seasons
Aire de concentration des adultes en saisons froides
Area de concentracion de los adultos en estaciones frias
Area of concentration of adults during warm seasons
Aire de concentration des adultes en saisons chaudes
Area de concentracion de los adultos en estaciones calientes

N.B. For topographical reasons, the scale of distances perpendicular to the coast has been artificially enlarged.

Figure 7 - Flat sardinella (*Sardinella maderensis)* in the southern sub-tropical zone: distribution and seasonal migrations (from Ghéno and de Campos Rosado, 1972, in FAO 1973)

the young spawners (15 to 25 cm) as well as the adults (> 25 cm) can be found both in estuaries as in the sea where, however, they stay close to the coast (Scheffers, 1973; Scheffers and Conand, 1976). Three distinct areas of distribution have been observed in Senegal each one associated with an estuary or with an estuarine area; Senegal, Saloum-Gambia and Casamance. It is not known what connexions there might be between the concentrations found in these different areas but differences in their biology have been noted.

In the Ivory Coast, the species reaches a maximum size of 30 cm, less than that found in Senegal. Spawning reaches its peak from November to May and is only known to take place in lagoons. The individuals stay there until they reach a maximum size of 20 cm and then migrate to the sea, i.e., before reaching their second year (Gerlotto, 1976). Sea fishery is still quite insignificant.

The bonga is fished from the Bay of Levrier in Mauritania (Maigret, 1972) to the Congo but it is particularly abundant from Senegal to Liberia and from Nigeria to Gabon. It is essentially the subject of artisanal type fishery with gillnets and beach seines and important fisheries exist in Senegal, Gambia, Guinea, Sierra Leone, Nigeria as well as in Cameroon. In the Ivory Coast it is mainly caught in lagoons.

1.2 Carangids

1.2.1 The black horse mackerel *(Trachurus trachurus* and *T. trecae)*

These two species are grouped together in fishery statistics under the same title: the black horse mackerel. One, *Trachurus trachurus*, tends to prefer a temperate climate and is captured North of the area being studied here, as far as Cape Verde (13°N); the other *T. trecae*, is more sub-tropical and tropical, and is found from North of Cape Barbas (24°N) down to South of Angola (Alfonso Días, 1974). In the northern sub-tropical region, the areas of distribution of both species mostly cover the area from Cap Blanc to The Gambia. It is the same South of the Gulf of Guinea in the southern sub-tropical region, for *T. trachurus capensis* (Fig. 8). In this sector it is said (a little arbitrarily), that the Cunene mackerel *(Trachurus trecae)* is found close to land while the cape mackerel would be more oceanic at least in the overlapping zone. The two species are especially abundant over the deep section of the continental shelf, and the young are generally found from a depth of 50 metres and the adults toward the edge of the continental shelf. As in the case of the round sardinella, it is in the areas of cold water upwellings outside the Gulf of Guinea (northern and southern sub-tropical areas) that the most important stocks of black horse mackerel are found.

In the northern sub-tropical area, the adults move along the coast in keeping with the shifts of the inter-tropical front (Fig. 3). With the *Trachurus trachurus*, breeding mainly takes place from November to January off-shore from Mauritania (between 20° and 26°N): this is the sector, therefore, where the young congregate. To the North and to the South of this area, the trawling fishery captures mostly large size adults (Boely *et al.*, 1973). The main breeding zone of *Trachurus trecae* is situated further South, between the Cape Verde Peninsula (14°45'N) and Cape Timiris (19°20'N). The spawning is spread over a period of time with a peak from February to June which shifts toward the North with the movement of the adults. In both species, the best captures are made on the pre-spawn concentrations. Except in Angola, the black horse mackerel are only of little interest for the moment to the coastal fisheries. Off Senegal and Mauritania, these species are only fished by long-range fleets, with the trawlers generally capturing individuals of all sizes while the seine fishery concentrates on individuals of more than 25 cm in size.

In the Angolan sector, the black horse mackerel fishery is, on the contrary, carried out by average size seiners based in the ports South of Angola (de Campos Rosado, 1974). *Trachurus trecae*, the main species, is fished between 10°S and 15°S. *Trachurus trachurus capensis* progressively takes over toward the South. Fishing by long-range trawlers only begins South of 15°S (Wengrzyn, 1976) and only becomes really important South of the Cunene River (Draganik, 1977). Little information is available on the movements of *Trachurus trecae* as well as on the identity of the various stocks present in this region.

In the Gulf of Guinea proper - i.e., from Guinea to the Congo - the black horse mackerel is not fished. *Trachurus trecae* is, however, regularly captured in quite considerable quantities, at least at the local level, from a depth of 50 metres to the edges of the shelf, either by commercial bottom trawlers or during prospecting voyages for demersal resources (Williams, 1968). Compared to the two previous sectors, outside the Gulf of Guinea, the individuals captured are of small size, generally less than 25 cm. The abundance in absolute terms of this species remains to be quantified; and this will call for the use of particularly well adapted gear and techniques (pelagic trawler, modifications for night and day fishing) and quantitative methods of acoustic prospecting.

1.2.2 The yellow horse mackerel *(Caranx rhonchus)*

The yellow horse mackerel is only fished in the northern sub-tropical area where it can be taken by most fishing gear: bottom trawlers, pelagic trawlers, seiners, gillnets, lines, etc., and it is of interest both to coastal fleets and ocean going ships (Boely, in press).

Its biology has certain similarities with that of the round sardinella *(S. aurita)*: with the main breeding season being from April to July, the growth of the juveniles in coastal waters and the migration of the adults along the coasts, from Guinea to Mauritania, in keeping with the seasonal shifts of the inter-tropical front (Fig. 3). The large-scale fisheries get their best results toward the edges of the shelf; with the seiners operating from January to April south of the Cape Verde Peninsula ($14^{\circ}45'$N) and the trawlers, on the other hand, from April to July, between the Cape Verde Peninsula and Cape Timiris (19°N). The fishery carried out by the latter involves the pre-spawning and spawning concentrations (Boely *et al.*, 1973). The fish caught are generally of large size (between 25 and 40 cm). The density increases from Cape Timiris to Guinea, with the northern limit of the species being around Cape Barbas (24°N). In 1973 and 1974, large catches of yellow horse mackerel were made by the ASTRA fleet off the Bissagos archipelago, between 10°N and 11°N (Boely and Østvedt, 1976). In Senegal, this species is fished in the cold season by seiners from Dakar on the one hand, and by local artisanal fishermen on the other; purse seines are used South of Dakar, and lines between Dakar and St. Louis. The total catch of these two countries, however, is not more than 5 000 tons (Freon *et al.*, in press).

The yellow horse mackerel is found all over the Gulf of Guinea, but it seems to be rare in the Bight of Biafra as well as off the coast of Liberia. It has been reported as common off Ivory Coast, and Ghana (where it appears in the catch statistics), and Congo.
As in the case of *T. trecae* we do not know of any movements within this area nor do we know of the absolute abundance. The species would seem to be small with a size of no more than 35 cm.

1.3 Other Species

1.3.1 Chub (= Spanish) mackerel *(Scomber japonicus)*

While it is reported all along the West African coast, this mackerel is also more abundant in the areas of cold water upwellings. Its biology is not well known. It is caught in the northern sub-tropical zone during the cold season and, in the hot season only, North of Cape Timiris (Elwertowski and Boely, 1971; Chabanne and Elwertowski, 1973). From December to March, around the Cape Verde Peninsula and further South, it forms pre-spawning concentrations which stay around the edge of the continental shelf. Juveniles are noted up until the end of the cold season from Dakar to Gambia.

Most catches are made between 26°N and 9°N; the largest individuals reaching a size of 40 cm. Seiners from Ivory Coast and Ghana also make some individual catches whose average size, while decidedly less, is still between 20 and 25 cm. It seems to be common off the Congo and North of Angola, but no large catches have taken place.

1.3.2 The blue fish *(Pomatomus saltator)*

The blue fish, which is classified among the main coastal pelagic fish, makes seasonal migrations along the African coast from Senegal to Morocco. In Senegal (from Dakar to St. Louis), it gives rise to an important artisanal fishery in the cold season (from December to June). In June-July, Polish and Soviet trawlers and, sometimes, Norwegian seiners, have fished the concentrations of pre-spawning fish which form around Cape Timiris (19°N). The abundance of this fish diminishes quite sharply South of Dakar. It has been reported as far as the Bissagos archipelago (10°N) and then again South of Congo (5°S).

2. THE MAIN FISHERIES

There are three main fisheries that compete in the exploitation of these species: artisanal fishery, local industrial fishery and large-scale fishery. The first two, practised by the coastal countries, bears mostly on the clupeids. In the northern sub-tropical area, the deep sea fishery carried out by countries foreign to the area, concerns both the horse mackerels and the chub (= Spanish) mackerel.

2.1 Artisanal Fisheries

The artisanal gear is characterized by its extreme diversity (castnets, surrounding and floating gillnets, long handlines, beach seines, etc.). They are generally handled from canoes and have scarcely evolved, at least in their principles, except for the recent adaptation of the ringnet seine to the canoe. On the other hand, the motorization of the canoes has profoundly modified the character of the artisanal fishery by permitting the fishermen to follow the movements of the fish; find new areas for fishing; diversify their catch and reduce the time spent in travel. The increase in supply has brought about a concentration of landing points. In Senegal, the motorization of the canoes, initiated in 1950, still continues and it can be estimated that in 1978 more than 80% of the fleet was equipped with outboard motors. In Ghana the same process has been reported, but the rate of motorization is less,and motorization, which began in 1960 (Østvedt, 1969), seems to have rapidly come to a standstill. In 1970, 2 000 canoes out of 8 000 had an outboard motor (Dykhuisen and Zei, 1971). Many of the canoes in Nigeria are motorized (Bayagbona, 1974) and also in Sierra Leone where 6 000 canoes have been counted (FAO, 1973). In Congo, all those of the "popo" type manned by Beninese, have a motor (Cayré and Fontana, 1977).

The artisanal fishery of pelagic fish has recently been transformed through the adoption of the ringnet and purse seine to the canoe. This was introduced to Senegal in 1973 and it is now found in Ghana and Ivory Coast (Gerlotto and Stéquert, 1978). It is also found in Gambia, Sierra Leone, Gabon and probably in Congo. Apart from the saving in time at the moment of capture there is a substantial increase in the volume of the catch and a diversification in the species caught (Grasset, 1972).

Artisanal fisheries are very active in Senegal, Sierra Leone, Ghana and Nigeria where they play a more important role than that of the industrial fishery. But the dispersion of landing points all along the coasts makes the qualitative and quantitative assessment of landings extremely difficult. Outside Senegal and Ghana the available information on the importance and evolution of artisanal fishery is rare and disparate. Most of the estimates given here are taken from the Statistics Bulletin of CECAF (FAO, 1979a).

Mauritania: In the Bay of Levrier there is an artisanal fishery using the surrounding gillnet, that is mostly carried on by fishermen coming from Senegal. No data are available but catches - probably mostly sardinellas - seem poor. South of Cape Timiris, there is also a traditional Mauritanian fishery ("imraguen" fishery) based originally on mullet during their pre-spawning migration (Maigret and Abdallahi, 1975).

Senegal: The artisanal fishery caught around 80 000 tons of pelagic fish in 1977 (Fréon *et al.*, 1979), broken down as follows:

- 6 000 tons of blue fish taken by line, most of them off the coast of northern Senegal;

- 3 500 tons of yellow horse mackerel, of which 2 000 tons taken by line North of Dakar and 1 500 tons with nets South of Cape Verde;

- 57 000 tons of sardinellas mainly with surrounding gillnets and purse seines, mostly from Dakar to Gambia;

- 6 000 tons of bonga mainly with gillnets South of Dakar.

The artisanal fishery in Senegal catches more than double that of the industrial fishery. In 1972-1973, fishery with surrounding gillnets produced around 35 000 tons of pelagic fish of which 65% were flat sardinellas, 20% bonga and 10% round sardinellas. After the introduction of the purse seine the specific composition of the catches changed. In 1977 the round sardinellas represented 50% of the catch, the flat sardinellas 35% and the bonga 10% (Fréon *et al.*, 1979).

Gambia: Artisanal fishery with floating and surrounding gillnets is carried out on the River Gambia and off the coast where it is mostly practised by fishermen coming from Senegal. In 1974, 10 000 tons of bonga were caught (Scheffers, 1976). The purse seine adapted to canoes is beginning to appear on the scene.

Guinea Bissau: No figures are available on artisanal fishery in this country. The flat sardinella and the bonga should be the dominant catch.

Guinea: 3 000 canoes of which only a part are motorized, catch around 7 000 tons of fish. The proportion of pelagic fish in this tonnage is unknown, but the flat sardinella and the bonga are predominant off the coast of Guinea.

Sierra Leone: In 1974, the artisanal fishery caught 40 000 tons of fish with gillnets, of which 23 000 tons were sardinellas - mainly flat sardinellas - and 15 000 tons of bonga. In recent years, the purse seine has begun to appear on motorized canoes.

Liberia: No figures are available on the artisanal fishery in this country.

Ivory Coast: Artisanal fishery in the sea only plays a secondary role. On the other hand, the catch of bonga in lagoons was around 14 000 tons in 1976.

Ghana: There is an important fleet of canoes both motorized and under sail. All the motorized canoes are engaged in the fishing of clupeids - mainly round sardinellas. In 1972, the catch of round sardinella reached a maximum of 72 000 tons (FRU/ORSTOM, 1976). The abrupt drop in 1973 and 1974, which followed this excessive catch, brought the volume of pelagic artisanal supplies in Ghana down to about 20 000 tons, mostly anchovy and flat sardinellas. With the collapse of the round sardinella catch, the catch of flat sardinellas has increased appreciably, probably through the increase of the effort devoted to this species in the eastern part of the country. Furthermore, Ghana is the only country in the Gulf of Guinea where variable but quite considerable amounts (at least at the local fishery level), of anchovy and mackerel are landed. In 1977 artisanal catches of round sardinellas returned to a normal level of 56 000 tons for these two species (FAO, 1979).

The development since 1974 of a fishery for small coastal tuna using gillnets of the "Anifa anifa" type should also be noted. Catches of frigate tunas *(Auxis thazard)* which were between 4 000 and 6 000 tons in 1974 to 1976 went up to over 2 000 tons in 1977.

Togo: 3 000 to 4 000 tons of unidentified clupeids are reported each year. They are mainly sardinellas.

Benin: Although reported catches are around the same as those for Togo, very little is known about the real importance of artisanal fishery which seems to be very active in the sea as well as in the lagoons. The clupeids, in particular the bonga and the flat sardinella, seem to represent an important part of the pelagic catch.

Nigeria: The artisanal fishery uses the gillnet on the bonga and the flat sardinella (Bayagbona, 1974). Most of the catch in clupeids for recent years, (which is in the order of 30 000 tons), is attributed to this fishery. The catches of over 100 000 tons reported in 1970 and 1971 seem to be erroneous.

Cameroon: The catches, made with gillnets, would seem to be over 10 000 tons a year and consist mainly of bonga.

Equatorial Guinea: Very little data are available on artisanal fishery which is of little importance.

Gabon: Catches in clupeids with gillnets are low, in the order of 1 000 tons per year. The introduction of the purse seine by fishermen from Ghana has been reported.

Congo: The production of the artisanal fishery increases regularly and would seem to have reached 6 000 tons in 1976, with the sardinellas making up about 80% of the catch. This expansion is due to the activity of fishermen from foreign countries (Benin and Togo especially). These use the motorized canoes, the number of which has gone from 10 in 1965 to 117 at the end of 1976. Their production represents 85% of the artisanal fishery (Cayré and Fontana, 1977). Most of the catches consist of flat sardinellas.

2.2 Local Industrial Fisheries

This type of fishery has been described in detail for Congo (Ghéno and Poinsard, 1969; Bouchereau, 1976), for Ghana (Ansa-Emmin, 1968) and Ivory Coast (Marchal, 1971a) and for Senegal (Boely and Chabanne, 1975; Fréon *et al.*, 1978). The boats are of average size with a length generally of between 13 and 25 metres. They all use purse seines, often with the Portuguese "cerco" rigging, of 300 to 750 metres long with a height between 35 and 60 metres. The fish are preserved on ice or in refrigerated sea water. The larger seiners are equipped with acoustic detection equipment and a power block. From Mauritania to Congo, most of the countries have various units of this type, but only Senegal, Ivory Coast and Ghana have fleets of a certain tonnage. The Senegalese, Ivory Coast and Congolese fleets seem to be the best equipped, although they are often made up of old boats. In Senegal, most of them had, in 1974, at least a vertical sounder and a power block. The fishery is coastal and the sardine boats generally do not go beyond 50 metres in depth. With the exception of the large Ivory Coast sardine boats which often operate off Sierra Leone, voyages are generally short and rarely last longer than 72 hours. The catch consists mostly of sardinellas. In Senegal and Ghana this type of fishery competes directly, in certain seasons, with the artisanal fishery.

By way of comparison, in 1973, 31 000 tons of fish were landed at Dakar by a dozen seiners, 27 000 at Abidjan from about 30 units, 18 000 in Ghana from 100 of the smaller seiners and 6 700 in Congo by two sardine boats.

Angola had an important seiner fleet of a very uniform type. Thus, in 1972, 360 Angola seiners spread over all the coast caught 570 000 tons of fish of which 140 000 tons were sardinellas caught mostly in the North of the country and 280 000 tons of horse mackerel landed in the southern ports (de Campos Rosado, 1974).

2.3 Large-scale Fishery

Large-scale fishery - in the sense used here - means the use of ships with great autonomy (several weeks or months), usually manned by crews from countries that are foreign to the sector being fished. In the case of coastal pelagic fish, this type of activity is practically confined to between 26°N and 9°N, i.e., to the sector that is by far the richest in the entire CECAF area. The ships used are big, from 35 metres (Dutch or Norwegian seiners) to 85 metres (trawlers from Eastern Europe). In general, the big trawlers process their catches themselves while the seiners and the smaller trawlers supply factory ships.

Exploitation had already begun in the region by 1958, with the arrival of Soviet boats, to be followed by boats from Poland (1962) and then Ghana (1964). Since 1966, the year when the pelagic trawl first appeared on the African coast (Czajka and Burawa, 1970), pelagic catches have been increasing and above all those of mackerel and horse mackerel. In 1970, six countries (Bulgaria, Ghana, Poland, the German Democratic Republic, Romania and the USSR) were fishing with trawlers on a regular basis for the pelagic stocks of this sector often working by day with a bottom wing trawl,by night with a pelagic trawl. The first seiners appeared in 1968 and the spectacular increase in catches between 1968 and 1970 can be accounted for by the arrival of fleets of this type; the Soviets in 1968 and 1969 (old S.R.T.N. trawlers transformed), the transnationals and the Norwegians in 1970.

The number and the composition of fleets operating between 26°N and 9°N is constantly changing, and the development of large-scale fishing is hard to follow. It would seem, however, that, for trawlers, the effort used by the overall fleets of Bulgaria, Poland and Romania has remained more or less stable since 1976. On the other hand, the Soviet fleet has continued to grow since 1965; in 1977 it was by far the most important of them all. As regards seiners, at the end of 1970 at least four Norwegian fleets could be counted ("Nordglobal" and "Astra"). Already in 1971 the annual effort developed by all these fleets combined was in decline. In fact, the numbers of the "Zuiderkreutz" seiner fleet (subsequently "Interpêche"), considerably diminished from 1972 onwards; the "Nordglobal" fleet only carried out one campaign a year from 1973 and in 1977 it finally abandoned the region. Finally, in May 1974, the factory ship "Astra" sank and since 1975, only the "Interpêche" group and the Soviet fleet operate in this sector. It is, however, possible that the increase in the number of Soviet seiners has partially compensated for the decline recorded in the effort used by the Norwegian and transnational fleets.

It must be added that the activities of the deep sea fishery have been, since 1973, disturbed by the progressive development of exclusive fishing zones by the coastal countries. Thus, since January 1973, the deep sea fleets no longer operate in Senegalese waters; and, likewise, fishing operations are controlled within a 30 mile limit of Mauritania and, since 1974, within 50 miles of Gambia. The seasonal cycle of the activity of these fleets, as described by Elwertowki and Boely (1971), Chabanne and Elwertowski (1973), Østvedt and Myklevoll (1975) has thus been profoundly altered. The fleets have often had to find new sectors for fishing. Thus, the fishing effort shifted, from January to May, toward the South to off-shore Guinea Bissau until, in 1976, this too was declared a reserved zone. From July to December, at least until 1976, the effort was concentrated to the North of Cap Blanc (21°N) for those fleets that were not authorized to work in Mauritanian waters. Since the end of 1976 Polish trawlers have been authorized to work in the coastal waters of Senegal.

South of the Gulf of Guinea, even though the Angolan region has important pelagic resources, high sea fleet exploitation was little developed until 1974. It only began to become really appreciable starting from 20°S. No high sea seine fleet has operated regularly between 5°S and 15°S. Only the W. Barentz fleet seems to have made some important catches during a few months in 1971 off the northern coast of the country, catching around 80 000 tons of fish (Ghéno and de Campos Rosado, 1972). Since 1975, German, Bulgarian, Cuban, Ghanaeans Japanese, Polish and Soviet trawlers have begun to fish in this sector for sardinellas and horse mackerel. In 1977, the USSR reported a catch of 86 000 tons of sardinellas (ICSEAF, 1979).

3. STATE OF RESOURCES

3.1 Available Data

Fishery statistics and biological data available for the assessment of stocks in the region suffer from several serious drawbacks. The CECAF documents are the main source of information. The statistical bulletins on catches (FAO, 1976a and 1979a) give annual nominal captures by fishing country and, to the extent that this information is reported, by species or groups of species and by statistical divisions. These bulletins are completed, upon request, by the states, giving the catches and corresponding efforts for the fisheries for which such data are requested and communicated to CECAF. Finally, there is a series of disparate information, particularly biological data, published or available in the archives of the laboratories involved in the study of stocks in the region.

3.1.1 Catches

The geographical distribution of catches is not always reported according to uniform criteria. While certain countries supply their data by the statistical divisions of CECAF, others (for example, Mauritania) only report them by larger geographical sectors, while yet others (USSR or Portugal) report for the region as a whole. The breakdown by species is also frequently insufficient and sometimes inexact. For example, two species of sardinellas, sometimes even the sardine, are declared under the same item. This is the reason why the two species of sardinellas cannot be evaluated separately and it is a serious gap in our knowledge, as the two species differ quite distinctly in their ecology, their distribution by depth and thus, consequently, in the exploitation which they suffer from the deep sea and the coastal fleets. The three species of horse mackerel (yellow and black horse mackerel) are not distinguished much better but for them the consequences are less important.

It is rare for catches to be broken down by gear. Thus, for the USSR, it is not known what portion of the catch is taken by seine, bottom trawl and pelagic trawl. The coastal countries only sometimes differentiate industrial catches from the artisanal catch. It is also very difficult to get an idea of the statistical coverage of artisanal fishery and of the trustworthiness of the estimates that are given. Finally, only very incomplete data are available on the composition, size and age of the catches. For this reason, we only know qualitatively what the division of fishing effort is on the various age levels of each population, and this is what has so far prevented the evaluation of certain interactions between various segments of the same fishery.

3.1.2 Fishing effort

Annual and sometimes monthly fishing efforts are available for certain fleets. It is, however, rare for these statistics to be sufficiently detailed to reduce the main sources of possible bias (change in target species and in the relative division of effort and species, saturation, improvements in efficiency as a result of technological innovation, better knowledge of stocks and their fishery on the part of the fishermen, etc.). We only know that they are many and numerous. For these reasons, and bearing in mind the great differences in the fishing characteristics, strategy and tactics of the various fisheries, it is not feasible to evaluate the total effort by adding up the partial efforts. Instead, an attempt has been made to select, by comparison, the series of cpue (either that of a fleet, or the average of a few of them) liable to give the least biased indication. An attempt has also been made to identify the sources of bias liable to seriously distort the series of cpue considered. The total fishing effort on a given stock has then been estimated in the classic fashion by dividing the total catch by the one or more selected cpue.

Because of the inadequate biological data and the absence of information on the population structure of the catches, recourse could only be made to global production models. In spite of the reserves mentioned earlier on the quality of the available statistical data they do, however, permit us to get a rough idea of the present state of exploitation of stocks.

3.2 Northern Sub-tropical Zone

3.2.1 General considerations

While this sector is the richest it is probably also the one where the fishery statistics are most lacking and where their interpretation, in terms of potential catch and levels of exploitation, are the most uncertain. One of the first difficulties lies in the assessment of quantities fished by species or groups of species (mackerel, horse mackerel, sardinellas and sardine). Table 5 shows the profound changes, as compared to previous reports, brought to the breakdown of Soviet clupeid catches into sardine and sardinellas. These new figures do not remove all the uncertainty on the relative importance of the sardine and the sardinellas in the USSR catch. It seems undeniable that, starting from 1973, sardine catches have greatly increased, in absolute as well as relative terms, since the old data, like the new, show that there must have been (although to a lesser degree), a simultaneous increase in the abundance of the sardine and of interest in its fishery. Nevertheless, the new Soviet statistics do not agree entirely with the observations published up to now on the size of sardine catches before 1973 and on the activity of various foreign fleets in the region (Elwertowski and Boely, 1971; Elwertowski *et al.*, 1972; Chabanne and Elwertowski, 1973). Furthermore, they are greater than the stock biomass estimated by Domanevski and Barkova (1978) mainly on the basis of Soviet catch statistics.

The difficulties become all the greater when it is a question of estimating the fishing effort incurred by each of the four large groups of species: mackerel, horse mackerel, sardinellas and sardine. Very little information is available on possible changes that may have come about in the interest shown in these four stocks. The effort data relate to the four groups of species overall. Starting from the information supplied in sections 2.2 and 2.3 above, some suppositions can be put forward that are subjective (but which are also essential in order to interpret the available data) on the probable evolution of the overall nominal effort. Starting from 1965, the following phases seem to have succeeded each other:

- up until 1969, progressive increase in fishing effort, mainly by large-scale trawlers;

- from the end of 1969 and for 1970, massive increase in effort following arrival on the scene of deep sea seiners;

- during the first years of this decade there has been a much slower, but probably a better, development of overall fishing effort;

- from 1972 to 1973, a complete unheaval in the system of fishery with, in particular: development of a sardine fishery North of Mauritania; development of a sardinella fishery by coastal fleets (sardine boats and canoes in Senegal and Gambia) and the occasional fishery by deep sea fleets in the coastal waters North and South of Senegal and Mauritania; finally, the possible decline in the overall effort and a decline in the effort exerted on the species and the age class exploited up to then off-shore from Senegal and Mauritania.

The development, in absolute and relative terms, of the annual catch for each of the four large groups of species (Fig. 9), enables us to make some qualitative observation on the way in which the distribution of overall fishing effort (by stock) has evolved:

- already in 1966, and at least until 1969, the effort seems to have mainly been brought to bear on the horse mackerel and the mackerel without there being any clear preference; the arrival of the large-scale seiners (1970) coincided with an increase in the fishery for sardinellas and for horse mackerel; catches of sardines increased from 1973 on;

- after 1970, i.e., before the effort had begun to decline very definitely off-shore (1973), we see a levelling-off in catches of the three main groups of species, followed by an apparent slow decline in 1970 for mackerel, in 1971-72 for sardinellas and only in 1974 for the horse mackerel. This could mean that the rate of removal had already reached, or even surpassed, the potential of these three stocks;

- the evolution in the relative importance of catches by stock (from which one expects to be able to see changes in the interest shown for different stocks and/or variations in their relative availability) leads to similar conclusions. One could think that interest in the horse mackerel and even for the sardinellas was quite high and, taken overall, quite stable until 1973. On the other hand, interest in the mackerel could have begun to diminish already in 1970 or else the drop in the percentage, and then in tonnage, of mackerel in the catches was due to the stock being exhausted;

- the figures concerning sardinellas and the sardine correspond to the new Soviet statistics. If the old had been more correct, the conclusions concerning the sardine would not have been modified, except as regards the importance in the growth of this fishery; on the other hand, those relating to the sardinellas would have been. According to the old data, the total catch for this stock - as far as their importance in the overall catch goes - remains stable, around 500 000 tons, starting from 1971.

3.2.2 Sardinellas

The cpue for sardinellas (Table 6 and Fig. 10) can be classified in two categories, depending on whether they correspond to the trawler fishery or the seiner fishery. The longest chronological series are those for the trawlers. Unfortunately, this species is not the target species for trawlers. There is a danger therefore that the corresponding cpue could give indications on abundance that are strongly biased. In fact, one can see that the Bulgarian cpue quite clearly went down from 1968 to 1976, while that for other fleets (Poland, Romania, USSR) practically remain stable during the same period. Although the seiners prefer to look for the sardinella, the series available for the off-shore seiners only refer to short periods. Furthermore, from 1973 on, the establishment of exclusive fishing zones has upset the geographical distribution of their operations and, therefore, the distribution by species and age classes of the fishing effort. The only series available that is both long and homogeneous corresponds to the sardine fishery in Dakar. But this is more in-shore and refers more than the off-shore fishery to the young fish and the flat sardinella. Thus, in 1977, the catches of young fish, coming from the Senegal-Gambia nursery area, by coastal industrial and artisanal fleets as well as the Polish fleet, were over 100 000 tons.

Up until 1972, the programme of the various fisheries remained stable. Using various hypotheses Elwertowski *et al.* (1972) have tried to assess the potential of pelagic stocks in the region. They have thus put forward the figure of 600 000 tons as the maximum potential catch for the two species of sardinellas together. It should be noted that this assessment has been derived from catch figures that are about 150 000 tons more than the latest data reported to the special CECAF working party on West African pelagic stocks from Mauritania to Liberia (FAO,1979a). The figure of 600 000 tons should, therefore, be reduced by this amount, which would bring it down to 500 000 tons. This estimate should be viewed with extreme caution since the data used to get it were not any better than the present statistics. During an acoustic survey carried out by the R/V CAPRICORNE in October and November 1974, a total biomass of 3.2 million tons of fish was registered between Cape Roxo (12°15'N) and Cape Barbas (22°20'N). On the basis of control fishing carried out simultaneously, information obtained on the catches of fleets in the area of the survey and the experience gained from previous campaigns, it has been estimated (Marchal and Boely, 1977), that the two species of sardinellas represent a biomass of 775 000 tons, distributed as follows:

South Senegal 1 Area (12°15'-13°25'N) : 14.10^3 tons
South Senegal 2 Area (13°25'-14°45'N) : 90.10^3 tons
North Senegal Area (14°45'-17°00'N) : 167.10^3 tons
South Mauritania Area (17°00'-19°10'N) : 103.10^3 tons
North Mauritania Area (19°55'-22°25'N) : 402.10^3 tons

These figures are underestimated. In fact, the survey did not cover, in latitude, the entire area of distribution of local stocks of sardinellas. The area North of Cape Barbas (22°20'N) was not surveyed. The same is true for the area within 19°55' and 19°10'N, to the South-West of the Arguin Bank, which is not very suitable for acoustic surveys. The Arguin Bank itself and important sectors off the South Senegalese coast have not been covered because of their shallow bottoms. On bottoms of less than 30 metres, the banks of sardinellas avoid the ship. Finally, sampling of detections could only be done with a trawler which sardinellas can avoid with relative ease,and no control fishing could be carried out in the area within 20°15' and 11°N, off the coast of Guinea Bissau. The causes for underestimating are thus multiple. Although it is impossible to quantify, it is certainly important and it would be reasonable to think that the total biomass of the overall stocks of

Table 3 Large-scale fishing: Annual catch (in tons) of sardinellas in the northern sub-tropical zone (26°N and 9°N)

Gear	Country	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Trawl	Bulgaria	-	-	-	37	1 845	5 606	2 604	952	3 624	165	582	212	261
	Cuba	-	-	-	-	-	100	1 400	-	-	-	-	-	-
	Ghana	2 778	4 621	3 853	600	3 712	4 428	4 928	142	179	2 662	5 760	9 453	13 294
	Poland	-	-	-	-	1 500	2 690	1 480	1 269	1 411	335	54	1 267	1 399
	Romania							74	647	3 303	4 232	1 188	1 821	611
Trawl and seine1/	German Dem. Republic	13	-	-	87	51	240	239	2 514	397				-
	USSR	3 700	1 100	5 000	6 400	27 000	30 000	35 000	40 000	45 000	50 000	55 000	59 388	51 245
Seine	Bermudas	-	-	-	-	-	-	120 000	136 000	136 000	128 119	73 485	146 835	65 903
	Norway	-	-	-	-	-	-	54 669	71 605	126 761	71 489	9 662	9 852	-
	South Africa	-	-	-	-	-	-	90 000	-	-	-	-	-	-
	Ivory Coast2/											(4 500)	(4 500)	(4 500)
Sub-total trawl		6 491	5 721	8 853	7 124	7 057	12 824	10 486	3 010	8 517	7 394	7 584	12 753	15 565
Sub-total seine		-	-	-	-	-	-	264 669	207 605	262 761	199 608	87 647	161 187	70 403
Total for all gear		6 491	5 721	8 853	7 124	34 108	43 064	310 394	253 129	316 675	257 002	150 231	233 328	137 213

1/ Until 1967, catches were made by trawl. After 1968 the distribution of effort between the different gear is unknown

2/ No report made to CECAF, nevertheless one or two big seiners catch from 1 000 to 3 000 tons of sardinella each year since 1974 in the Bissagos and in the South of Senegal

Source: CECAF Statistical Bulletins and communications from the various countries in the special CECAF working party on West African coastal pelagic stocks from Mauritania to Liberia, Dakar (Senegal), 19-24 June 1978 (FAO, 1979a)

Table 4 Total annual catch (in tons) of sardinellas in the northern sub-tropical zone

Year	Large-scale fishery[1]	Senegal		Mauritania	Total catch
		Industrial fishery	Artisanal fishery		
1964	6 491	4 063	22 900	3 000	36 454
1965	5 721	4 702	23 300	3 900	37 623
1966	8 853	6 445	22 600	5 400	43 298
1967	7 124	5 217	20 800	5 610	38 751
1968	34 108	8 857	21 100	6 510	70 578
1969	43 064	14 477	17 500	7 800	82 841
1970	310 394	13 643	26 400	13 200	363 637
1971	253 129	11 480	30 500	17 361	312 470
1972	316 675	21 722	31 300	8 895	378 593
1973	257 002	26 206	32 800	7 173	323 181
1974	150 230	27 774	40 200	7 770	226 100
1975	233 330	21 927	46 100	-	301 355
1976	137 210	26 729	51 300	-	215 240

[1] Catches of sardinellas by small Ghanaean seiners based in Gambia have, for convenience, been added in with the large-scale fishery

Table 5 Large-scale fishery in the northern sub-tropical zone: Comparison of the old and the new Soviet statistics on sardine and sardinella catches

	Previous estimates[1]			New estimates[2]		
Year	USSR		Total deep sea fishery (sardinellas)	USSR		Total deep sea fishery (sardinellas)
	Sardinellas	Sardine		Sardinellas	Sardine	
1964	3 700	-	6 491	3 700	-	6 491
1965	1 100	-	5 721	1 100	-	5 721
1966	5 000	-	8 853	5 000	-	8 853
1967	6 400	-	7 196	6 400	-	7 124
1968	22 000	-	29 076	27 000	-	34 108
1969	110 100	-	123 060	30 000	80 100	43 064
1970	123 700	-	416 476	35 000	88 700	310 394
1971	147 200	16 400	366 808	40 000	123 600	253 129
1972	122 400	13 600	394 987	45 000	91 000	316 675
1973	184 300	21 500	387 832	50 000	155 800	257 002
1974	308 000	34 200	449 822	55 000	287 200	150 230
1975				59 388	297 795	233 330
1976				51 245	514 978	137 210

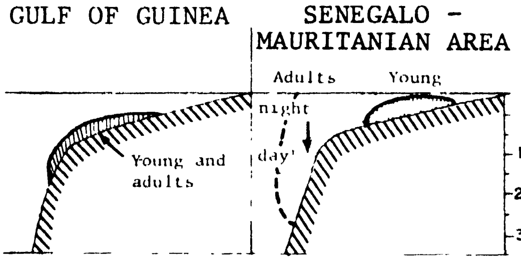
[1] Boely, 1978

[2] FAO, 1979a

Table 6 Deep sea fishery for sardinellas in the northern sub-tropical zone.
Efforts and catch per unit effort of some trawler and seiner fleets (FAO data, 1979a)

Year	Trawler fleets							Seiner fleets				
	Bulgaria		Poland		Romania		USSR	Norway "ASTRA"		"INTERPECHE"		USSR
	Effort 24 h	cpue t/24 h	Effort 24 h	cpue t/24 h	Effort 24 h	cpue t/24 h	cpue t/24 h	Effort 24 h	cpue t/24 h	Effort 24 h	cpue t/24 h	cpue t/24 h
1966												
1967	273	0.1										
1968	369	5.0	1 587	0.9								
1969	895	6.3	2 416	1.1								
1970	1 170	2.2	1 888	0.8	343	0.2		2 259	23.4	-		
1971	588	1.6	1 842	0.7	999	0.6	2.0	2 222	18.0	-		
1972	693	5.2	1 468	1.0	1 487	2.2	0.7	2 094	33.1	-		
1973	524	0.3	1 237	0.3	1 909	2.2	0.7	2 054	27.6	2 954	43.4	2.9
1974	369	1.6	1 088	0.05	2 914	0.4	0.9	347[1]	16.3[1]	2 455	29.9	1.5
1975	1 075	0.2	2 818	0.4	3 046	0.6	2.0			2 225	66.0	1.9
1976	531	0.5	4 163	0.3	1 457	0.4	0.8			1 277	51.6	2.2

[1] From January to May 1974 in Guinea-Bissau



Distribution by depth of *Trachurus trecae*

Modal sizes (l, cm) of catches in the different fisheries

SPECIES	CARANX RHONCHUS		TRACHURUS TRECAE		TRACHURUS TRACHURUS	
FISHERIES	coastal	off shore	coastal	off shore	coastal	off shore
MAURITANIA		25-35	-	15-35	-	15-35
SENEGAL	10-35	25-35	10-35	15-35	-	35
GUINEA BISSAO		30-35	-	-	-	-
IVORY COAST GHANA	25-30	-	-	-	-	-
CONGO	-	-		-	-	-
ANGOLA	-	-	-	-		20-40

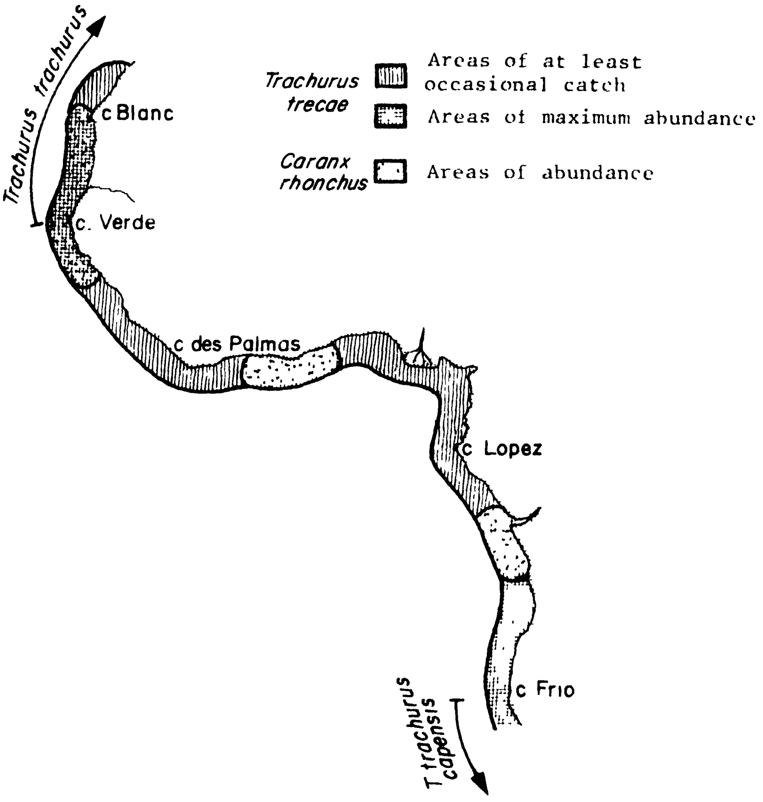


Figure 8 - Horse Mackerel (*Trachurus trachurus*, *Trachurus trecae* and *Caranx rhonchus*). Principal areas of abundance and fishing, main size classes in the various fisheries and distribution by depth of the main strata of the population.

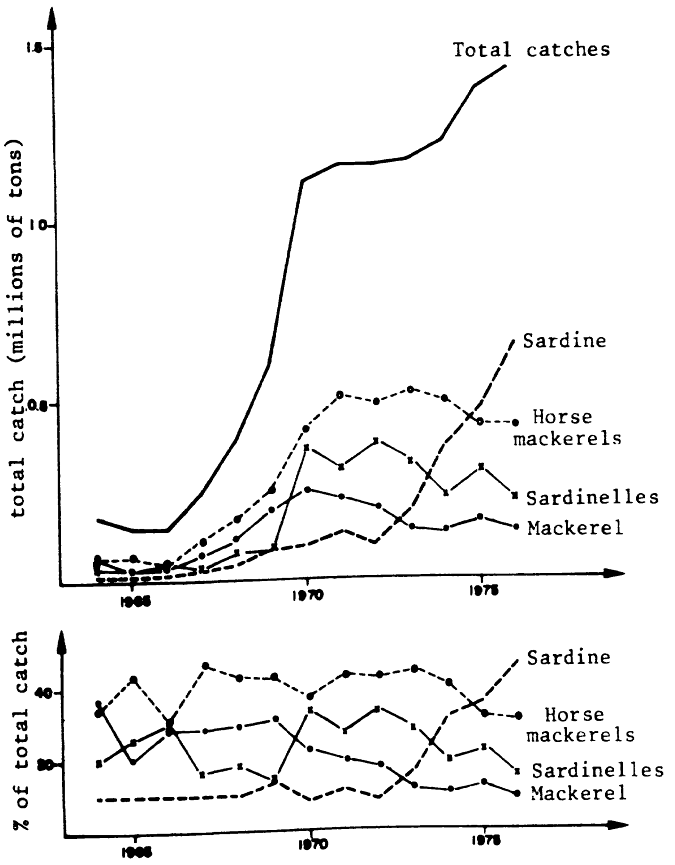


Figure 9 - Northern sub-tropical zone: evolution of catches in tons (top) and in percentages of total (bottom) for each of the four main groups of species.

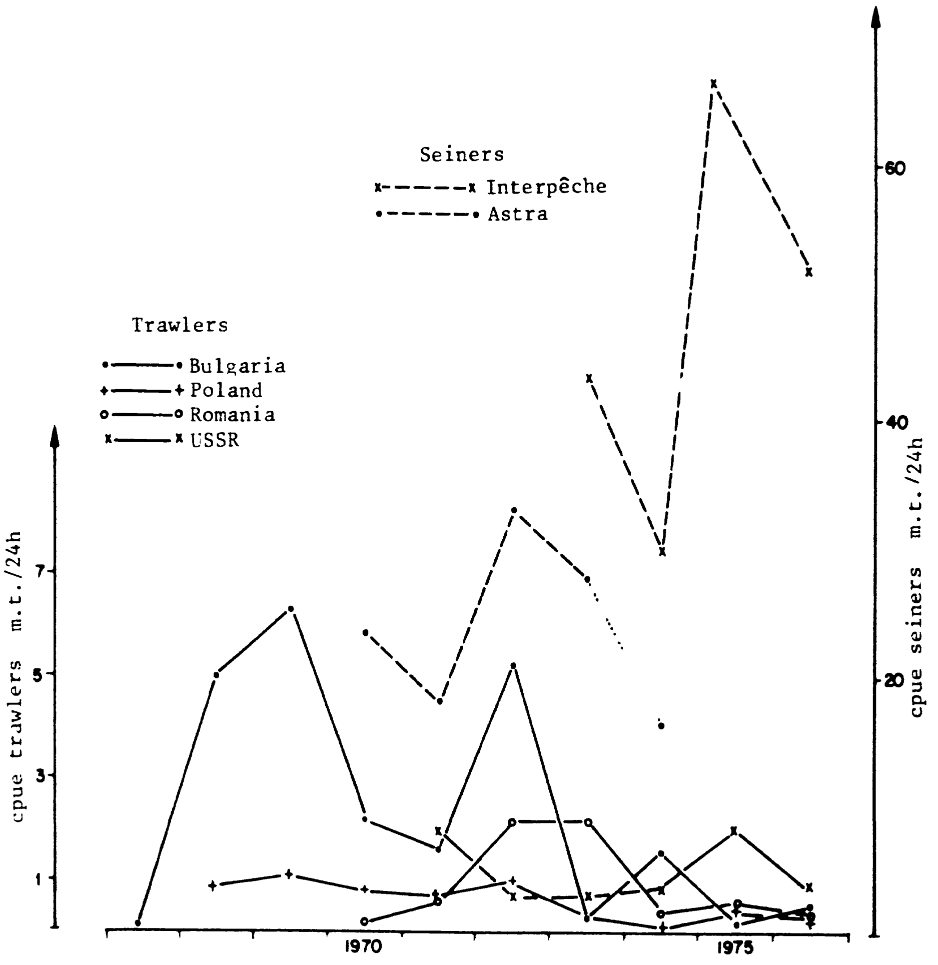


Figure 10 - Sardinellas in the northern sub-tropical zone: evolution in the cpue of some deep sea trawlers and seiner fleets (CECAF data).

sardinellas in the northern sub-tropical zone is not, at the moment of assessment, less than one million tons.

The interpretation of this assessment of the biomass, in terms of potential maximum catch, is difficult as the rate of exploitation of the stock at the moment of the survey is not known. Nevertheless, with the observations that have already been made, we can still get certain indications of the possible lower and upper limits on this potential. Already it can be said that from 1970 to 1973, i.e., over four successive years, the catches varied around 350 000 tons (or 450 000 tons, depending on whether the latest or the older statistics are used). For animals with a short life span such as the sardinellas, the stock should, in practice, be balanced in less than four years, and even if a portion of these catches can correspond to a reduction of a biomass still underexploited, it is probable that the potential is not much less than this figure.

In the introduction to section 3.2, it was pointed out that the drop in catches for sardinellas noted after 1972 could theoretically be due to a partial overexploitation of the stock, although the transfer of a part of the fishing effort to the sardine seems to have been the more probable reason. The assessment of the biomass by survey throws some light on this point. If at the end of 1974, at the time of the survey, the stock had been exploited to the maximum of its possibilities, its potential would then have been, on the basis of the Schaefer model and assuming that at this level of exploitation F is close to M, equal to (Gulland, 1971)

$$C_{max} \approx F : B_{max} \approx M\ B_{max} \approx 0.5\ MB_{o}$$

By taking 0.4 to 0.6 as the more probable interval value for M the potential in this hypothesis would be around 400 000 to 600 000 tons. It would be even higher than this figure in the case where the stock had been overexploited in 1974 and thus, where its biomass would have then been less than B_{max}. In the opposite case it would be lower. If we now consider in this light the two series of catch assessments we have available (Tables 4 and 5), we can see that the old series indicate that in 1974 catches had reached their maximum with 525 000 tons. This figure is of the same order as the maximum balanced production put forward earlier. Previously, catches had remained around 450 000 tons for four years (1970-1973); they were much lower in the sixties. According to this information, the stock should have been fully exploited in 1974 but the exploitation would never seem to have reached levels that were clearly excessive.

The new series of data (Table 4) suggest catches of 226 000 tons in 1974, preceded by much bigger catches over four years (310 000 to 380 000 tons). In this case, one may wonder, therefore, if, at the time of the acoustic survey, we were on the ascending or descending part of the production curve. If we were on the descending section (overexploitation), the maximum balanced catch would be greater than the values 400 000 to 600 000 tons previously calculated and, for this reason, landings should have at least been around comparable values over the years prior to 1974. Since this was not the case, one could suppose that the drop in catches registered in 1974 corresponds to a drop in the fishing effort exercised on sardinellas, probably as the result of part of the available effort being switched over to the sardine. Such a supposition would agree with the fishing mortality as it can be estimated on the basis of the ratio of catches in 1974 and the biomass estimated by echo sounding in the same year ($F = 0.15$): such a figure can be considered as moderate for a coastal pelagic species with a short life.

In the end, the two series of data allow us to fix the balanced minimum production of the stock at close to 350 000 tons per year since this production has, on the average, been sustained during four consecutive years without any apparent overexploitation. This reasoning supposes, of course, a certain stability in recruitment. The first series of data will allow us to put forward a maximum limit of 400 000 to 600 000 tons per year. The assessment done by Elwertowski *et al.* comes within this range. However, we should note that these results are based in part on very crude assessments of the biomass and the M coefficient.

Given the data now available, it is not possible to refine this assessment. In view of the lack of adequate information and the time it will take before this situation is improved, it is better to be cautious. Until more information is available it should be wiser, in using these figures for the planning of any development, only to consider the lower half of this range as an order of magnitude of the catch potential offered by the stock.

3.2.3 Horse mackerel

Some statistics are available on catches and effort for the period 1965-1976 (Tables 7 and 8). The related cpue are shown in Fig. 11. These cpue refer overall to the three species of horse mackerel. Two of them *(Trachurus trachurus* and *Trachurus trecae)* have a similar ecology and represent close to 80% of the total of horse mackerel that are caught. The predominance of *Trachurus trachurus* would seem to have grown again these recent years following, it seems, a new distribution of fishing effort. The series thus calculated show as many differences as similarities in their variations. Only the cpue for the Bulgarians, Romanians and Poles (up until 1973) show a parallel evolution. Allowance made for differences in scale, the cpue for the "Astra" and "Interpêche" seiner flotillas are basically not much different. We have seen that the drop in yields after 1972 in the Polish fleet is probably explained by the shift northward of boats more interested in fishing the sardine.

On the other hand, expressed in the same scale, the Soviet series show an evolution that on all levels is the contrary of that for the Bulgarian, Polish (up until 1972) and Romanian fleets: the yields of the first mentioned increase up until 1967/69, then drop until 1973, only to start increasing again. It can be seen that the successive maximums and minimums coincide in the two series and correspond to critical periods for the fishery: the arrival of the large-scale seiner fishery in 1969/70, and the development of a sardine fishery after 1973. Apparently, the Soviet fleets on the one hand, and the Bulgarian, Polish and Romanian fleets on the other, have not reacted in the same way to these events, particularly as regards their interest for the horse mackerel.

In these conditions, it is difficult to say which of the two series of cpue (if there is one, and within these, which period), accurately represent the evolution of the biomass, particularly in relation to the variations in the rates of exploitation. Before discarding these data, the total effort corresponding to each of the two series of cpue was extrapolated by dividing, in the classic manner, the total catch by the cpue considered. The ratio between the cpue and the total effort calculated in this way (averaged for two years) was then subsequently analysed according to the classic treatment of a global production model. This attempt confirmed that the data cannot be utilized on a production model. We see, in fact, from 1968 to 1973 for the Bulgarian/Polish (without the figures for 1973/76)/Romanian series, an appreciable growth of cpue for a relatively moderate drop in the total estimated fishing effort. A comparable evolution is also noted for the Soviet series but from 1973 to 1976! It is thus impossible, that the two series usefully represent the effect of the fishery on the stock: this effect is totally hidden in one (if not both), series. The apparent variations in cpue would seem to be caused at least as much by other factors as by the rate of exploitation. Here one can think, first of all, of changes in the interest which each fishery shows for the various stocks capable of being exploited simultaneously. Nor can we any longer - *a priori* - set aside the hypothesis that these fluctuations are partly the result of natural changes in the relative size of the different stocks. Whatever their origin, these fluctuations make it impossible to determine, on the basis of the available data, the relationship between the cpue, i.e., the biomass and the rates of exploitation and, consequently, of the stock potential.

It is interesting to note that the various partial series of cpue (Soviet 1969/73, Soviet 1973/76, Soviet 1969/76, Bulgarian-Polish-Romanian 1969/76) that one could, *a priori*, use to try to determine the relationship stock abundance/pseudo-balanced effort, all lead, even when their slopes and their intercepts originally differ quite appreciably, to an "equilibrium production curve" which always gives a maximum close to half a million tons. This is probably related to the fact that all these calculations are carried out with the same total catches vector. These remain within 415 000 and 515 000 tons (average 465 000 tons)

Table 7 - Northern sub-tropical zone: catches (tons) of horse mackerel
(*Trachurus trachurus*, *Trachurus trecae* and *Caranx rhonchus*) (Source: FAO, 1979a)

Gear	Country	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Trawlers	Bulgaria				1 472	359	6 066	9 805	3 293	8 203	9 238	7 318	10 698	9 247
	Cuba							8 700	1 100					
	Ghana	3 200	8 955	7 150	16 216	10 927	2 589	19 783	4 019	4 625	2	2 649	5 548	2 134
	Japan	5 995	8 512	5 483	6 210	6 032	11 143	7 785	4 649	5 304	9 388	6 726		
	Poland	1 461	5 804	6 255	7 890	4 528	10 697	12 976	9 790	13 495	7 117	4 306	6 555	12 204
	Portugal			700	400	400	500	300	400	500	923	553	618	594
	Romania							2 400	7 289	19 571	30 750	39 334	29 652	14 144
	Greece			647	137	333	176	253	271	66	3			
Trawlers and seiners	Korea											64	249	
	GDR	156	-	14	9 387	1 787	1 241	4 730	11 524	2 356				
	USSR	46 400	35 200	20 900	67 600	140 400	215 700	232 400	329 600	332 300	335 500	360 300	344 132	365 069
Industrial seiners	Bermudas*							30 000	34 000	34 000	26 539	5 321	10 332	13 965
	Norway							36 205	92 347	60 856	93 478	55 279	12 511	
	South Africa*							45 000						
Coastal seiners	Senegal	3 500	3 500	3 900	3 900	4 100	3 100	4 500	2 900	2 500	4 100	4 700	4 700	5 100
	Mauritania								89	50	89	1 187	1 657	1 103
TOTAL		60 712	61 971	45 049	113 212	168 866	251 212	414 837	501 271	483 826	517 127	487 647	426 652	423 560

* Data estimated up to 1972. After 1973, figures supplied directly by the company "INTERPECHE"

Table 8 - Horse mackerel in the northern sub-tropical zone: Efforts and catch per unit effort of some high sea fishing fleets (Source: FAO, 1979a)

			Years											
			1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Trawlers	Bulgaria	Effort 1/			273	369	895	1170	588	693	529	369	1075	531
		cpue			5.4	1.0	6.8	8.4	5.6	11.8	17.5	19.8	10.0	17.4
	Poland	Effort 1/	871	1120	1238	1587	2416	1888	1842	1468	1237	1088	2818	4163
		cpue	6.7	5.6	6.4	2.9	4.4	6.9	5.3	9.2	5.8	4.0	2.3	2.9
	Romania	Effort 2/						343	999	1487	1909	2914	3046	1457
		cpue						7.0	7.3	13.2	16.1	13.5	9.7	9.7
	USSR	cpue 3/	9.1	7.6	18.2	13.1	18.5	17.1	14.8	12.2	11.9	16.9	20.5	25.8
Seiners	INTERPECHE	Effort 4/									2954	2455	2225	1277
		cpue									9.1	2.1	4.6	10.9
	Norway (ASTRA fleet)	Effort 4/						2259	2222	2094	2054			
		cpue						14.5	18.0	19.6	27.8			

1/ Fishing effort normalized and expressed in fishing days (24 h) for a Polish B23 type trawler
2/ Fishing day (24 h) of a Romanian trawler
3/ Catch per fishing day (24 h) of a Soviet trawler (only unit available)
4/ Fishing day (24 h) of a 35 m seiner

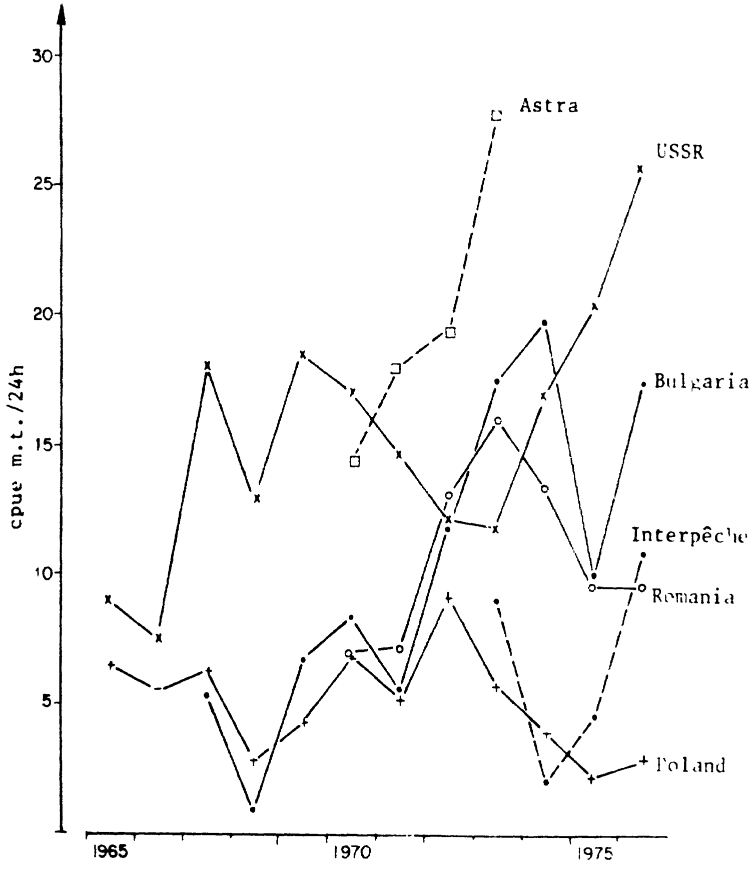


Figure 11 - Horse mackerel in the northern sub-tropical zone: evolution of various cpue relating to large scale fleets (CECAF data).

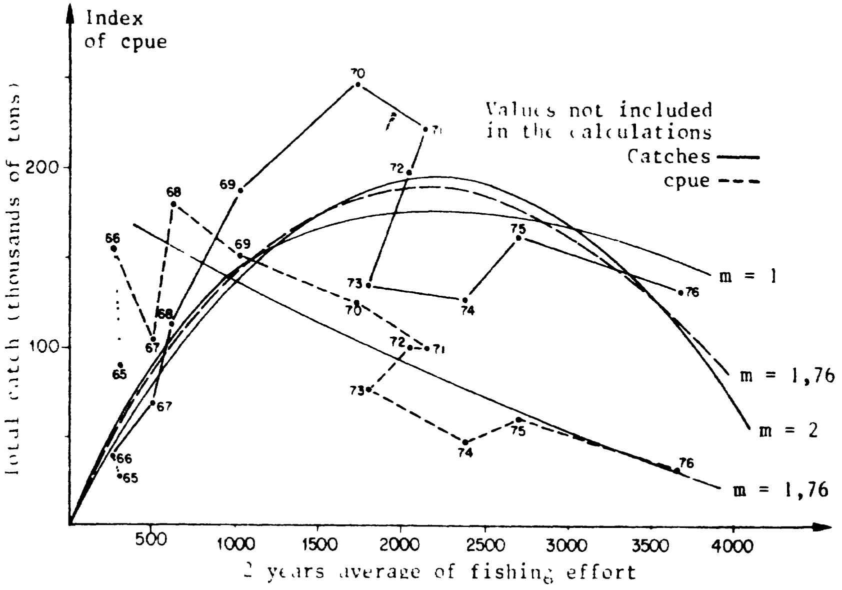


Figure 12 - Mackerel in the northern sub-tropical zone. Relationships between the total catch, index of abundance (combined cpue) and the total pseudo-equilibrium fishing effort (equilibrium curves adjusted with the help of the PRODFIT programme).

from 1970 to 1976. Bearing in mind the length of time during which these catches were maintained, the stock should be able to bear a catch of this order on a continual basis. However, there is no reason to think that the potential maximum catch could not be higher. It is not known, in fact, whether catches have stabilized at this level because the stock could not produce more or because the total effort applied to this stock had itself levelled off.

Elwertowski *et al.* (1972) applied a global production model to the data relative to the period 1967-1971 and concluded with a maximum catch potential in the order of 700 000 tons. While this is comparable with the previous conclusions, no more confidence can be placed in this figure since the data used in both cases are not the best; in fact, the assessment of Elwertowski *et al.* is based on a shorter period.

Using acoustical assessment methods, Marchal and Boely (1977) made an estimate for November 1974 of around 1.3 million tons for the horse mackerel biomass available between Cape Roxo and Cape Barbas. This biomass was distributed as follows:

- South Senegal zone 1 (12°15'-13°25'N) : 44.10^3 tons
  (mainly *T. trecae* of small size)
- South Senegal zone 2 (13°25'-14°45'N) : 96.10^3 tons
  of which 89 000 tons of *T. trecae* of small size
  7 000 tons of *C. rhonchus*
- North Senegal zone (14°45'-17°N) : 152.10^3 tons
  of which 138 000 tons of *T. trecae*
  14 000 tons of *C. rhonchus*
- South Mauritanian zone (17°-19°10'N) : 369.10^3 tons
  of which 347 000 tons of *Trachurus* spp.
  22 000 tons of *C. rhonchus*
- North Mauritanian zone (19°55'-22°25'N) : 618.10^3 tons
  of which 196 000 tons of *T. trecae*
  304 000 tons of *T. trachurus*
  118 000 tons of *C. rhonchus*

Here too, the real biomass is certainly underestimated, since the assessment does not cover all the area of distribution of the Senegalese-Mauritanian horse mackerel. In particular, it does not cover North of Cape Barbas up to 26°N, between 19°10' and 19°55'N and, to the South, in Guinea Bissau. The other causes for underestimation (avoidance of sand banks, coastal zones and inexplorable high bottoms, samplings, etc.) are less important in the case of horse mackerel than for sardinellas, the former not living in shallow bottoms and being more vulnerable to trawling. On the other hand, it is thought that a relatively more abundant part of the stock should be found North of Cape Barbas and this has not been covered. It would seem, therefore, that a minimum biomass consists of between 1.5 and 2.0 million tons making this a reasonable first estimate for the Senegal-Mauritanian region.

As in the case of the sardinella, this estimate can be used to calculate the lower and upper limits of the maximum sustainable yield if we admit that for horse mackerel M is to be found between 0.4 and 0.5. In this hypothesis, if the stock had been fully exploited at the time of the survey ($F \simeq M$), its potential would be equal to MB_{max}, i.e., in the order of 600 000 to 1 million tons at least. It would be even more in the case where the stock had been overexploited at the time of the survey and would be less if the opposite were the case. Now, up until the survey took place, catches had never reached this level, and they had stayed at 500 000 tons per year from 1971 to 1974. The first conclusion to be drawn is that the stock has never been overexploited before 1974 ($F = C_{1974}/B_{1974} = 0.3$) and it would be in the position to support over a long term catches equal or superior to 450 000 tons, which is the level at which catches were maintained over a period of seven years (always supposing that there is a relatively stable recruitment). As in the case of the sardinella, the lack of precision in these estimates means that for development plans, we should take the values that come in the lower limits of the bracket until supplementary information is available to make the assessment more precise.

The estimate of potential would seem to be, therefore, between half a million and probably less than a million tons. This evaluation is not precise. It should be noted that the extent of this range is probably in reality not so great. We know, in fact, that evaluations based on global models applied to statistics of a fishery are nearly always less than those obtained on the basis of estimates by survey of the total biomass. We will find several examples of these divergences in the present study. The reason for these divergences lies, first of all, in the fact that biomass actually exploited is often less than the biomass theoretically exploitable, and also in the fact that for operational reasons and the availability of stock, it is impossible to realize an optimum distribution of the fishing effort over the space, the seasons and the different age classes.

3.2.4 Mackerel stock

In the Senegal-Mauritanian area, this species is caught both by trawl and by seine and only concerns large-scale fisheries. During the initial stage of the fishery it constituted the main target for the mid-winter trawlers. Catches reached a maximum of 250 000 tons in 1970 and have gone down steadily since then (Table 9, Fig. 9). As yields were already diminishing in 1968, some fleets preferred to devote their attention to other species, in particular, the horse mackerel and then to the sardine as was mentioned earlier. Quite precise statistical data are available on the mackerel due to the fact that it is generally not confused with other species. However, some reservations must be made for what concerns Portuguese reportings. First of all, between 1966 and 1971 the localization of the catches was badly defined and, as a result, considerable part of the European mackerel *(Scomber scomber)* could be included.

At a special CECAF working party on coastal pelagic fish in West Africa from Mauritania to Liberia (Dakar, Senegal, June 1978), several ratios between indices on abundance and effort were tried by using as an abundance index the cpue of the Soviet trawler fleet, or a combined cpue, taken from data concerning the Bulgarian, Polish, Romanian and Soviet fleets. In all these cases we can note a definite tendency toward a reduction in the abundancy index when the fishing effort grows. Reservations have, however, been expressed both as regards the quality of the data and to the possible underassessment of abundance, these last few years, following on the probable reports of a part of the fishing effort (FAO, 1979a). According to the distribution of points in Fig. 12, such a displacement, if it is quite possible for 1973 and 1974, is not at all evident in 1975 and 1976. It could thus be that the drop of interest in the mackerel did not last longer than 1974.

Bearing in mind these reservations, the data were used in a global production model. The combined index of cpue mentioned above was retained. The total effort in an equilibrium situation has been simulated by taking the average efforts of the year in course and the previous year, the exploitation affecting scarcely more than two age classes. The PRODFIT programme was used to calculate the production and yield curves corresponding to $m = 2$ (linear) and $m = 1$ (exponential). The value of m corresponding to the best adjustment of the curve at the points observed (according to the criteria of the least squares) is 1.76.

According to these results, (Table 11 and Fig. 12) that are all fairly close to each other, the potential would be slightly less than 200 000 tons and the stock has been overexploited since 1974. The effort corresponding to maximum sustainable yield would have been reached in 1971-72. To take into account the possibility of a certain lack of interest in the mackerel fishery in 1973 and 1974, a similar calculation (exponential function, reduced major axis, effort averaged over two years) was made in the ratio cpue/effort while this time excluding the values for 1973 and 1974. With this system, the potential assessment was 205 000 tons. The corresponding effort is very close to the results given in Table 11.

Table 9 - Mackerel in the northern sub-tropical zone: total catch (tons) per country and method of fishing (Source: FAO, 1979a)

Gear	Country	Year												
		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Trawlers	Bulgaria				2 274	2 721	10 341	16 416	5 345	3 178	1 323	1 046	3 204	540
	Ghana		2 422	5 062			3 857	6 533	401	504		51	1 338	308
	Greece	916	582	265	255	636	224	353	168	174	174			
	Japan	1 859	879	1 043	1 668	1 878	1 571	217	91	68	134	306		
	Poland	2 696	2 436	7 461	8 828	8 558	6 871	3 118	3 009	2 685	1 189	749	1 264	1 722
	Romania							1 611	4 900	6 726	6 187	4 986	9 409	2 144
	Portugal[1]			12 900	16 400	10 200	21 400	39 300	20 400	196	507	328	359	410
Trawlers and seiners	German Dem.Rep.	236		143	6 175	2 989	2 394	19 777	20 521	1 933				
	USSR	60 600	22 000	12 900	32 200	85 800	141 100	139 700	130 100	174 800	122 700	119 600	142 646	126 938
Seiners	Bermudas							0						
	South Africa							15 000						
	Norway							5 088	36 786	5 887	1 926			
Coastal seiners	Senegal								108	55	47	100	3 037	52
TOTAL		66 307	28 319	39 774	67 800	112 782	187 758	247 113	221 829	196 206	134 187	127 166	161 257	132 114

1/ An unknown part of the catch was made north of 26°N

Table 10 - Mackerel in the northern sub-tropical zone: total yearly catch (tons), combined index of cpue and corresponding estimated total effort (Source: FAO, 1979a)

Year	Catch (tons)	Combined index of cpue[1/]	Estimated total effort
1965	28 319	(90)	(315)
1966	39 774	156	255
1967	67 800	104	650
1968	112 782	180	626
1969	187 758	152	1 235
1970	247 113	125	1 977
1971	221 829	99	2 238
1972	196 206	101	1 950
1973	134 187	77	1 733
1974	127 166	47	2 706
1975	161 257	60	2 687
1976	132 114	32	4 129

1/ Combine Bulgarian, Polish, Romanian and Soviet cpue

( ) Values not utilized

Table 11 - Mackerel in the northern sub-tropical zone. Balanced values calculated by the PRODFIT programme for various hypothetical values for m

Value of m	1.76	2	1
Balanced maximum catch (tons)	188 000	194 000	175 000
Index of error	10%	7%	8%
Corresponding effort (index)	2 100	2 200	2 100
Index of error	10%	5%	17%
Corresponding cpue (index)	89	88	82
Index of error	10%	9%	15%

An evaluation by Elwertowski *et al.* (1972) gave a maximum sustainable yield of 170000 tons of mackerel, a figure that is comparable to the evaluations given above.

In this connexion, using an acoustic survey, Marchal and Boely (1977), calculated 120 000 tons of mackerel biomass present in October-November 1974 over that portion of continental shelf that lies between Cape Roxo and Cape Barbas. This biomass is the equivalent of the total mackerel catch in 1974 and it is less than the estimates of the balanced maximum catch that have been given above. This low value for the biomass estimate could be due to the fact that the area surveyed in no way covered all the area of stock distribution. In fact, even more than in the case of the horse mackerel, we have a very poor idea of the northern limits of the Senegal-Mauritanian mackerel stock, and it is quite likely that its area of distribution goes still further North, into the Moroccan area.

3.3 The Gulf of Guinea

This area which is considerably bigger than the previous one, only supplies around a fifth of the pelagic catch of the entire sector being studied here. Given the less abundance of resources, large-scale industrial and foreign fisheries are, on the whole, not very active in the area. The artisanal fishery - which is important for several countries - and local fleets of average size seiners land almost the entire supply. The difficulties in sampling widely dispersed artisanal fleets and in setting up workable statistical systems explains why the data are still quite uncertain for several countries.

The sector is not homogeneous. The central portion (Ivory Coast, Ghana, Togo and Benin), benefit from a seasonal upwelling, which is not the case to the West (South Sierra Leone and Liberia) nor to the East (Nigeria, Cameroon, Equatorial Guinea and North Gabon). The differences in environmental conditions and the resulting productivity affect the distribution and the richness of the pelagic stocks.

3.3.1 Sherbro Division (the coasts of Sierra Leone and Liberia)

In thirteen years the reported catches for this statistical division have doubled, going from 24 000 tons in 1964 to 53 000 tons in 1976 (Table 12). In fact, they have levelled off around 55 000 tons since 1971. In this connexion, it has been noted that in 1970 there was a sudden jump in the catch statistics for sardinellas reported by Sierra Leone; this was mainly the result of a better statistical coverage of the artisanal supply.

The largest part of the production comes from the Sierra Leone sector, where considerable concentrations of flat sardinella and bonga in the coastal strip have permitted the development of a vigorous canoe fishery. Further off-shore - especially North of the Island of Sherbro - concentrations of round sardinella, yellow horse mackerel and mackerel are found on a seasonal basis. Since 1969, Ivory Coast sardine boats come to fish on these bottoms for the flat and round sardinella concentrations. The flat species dominates in the catches, while the second species, depending on the year, represents not more than 10 to 30 per cent of the total. No drop has been evident in the cpue available for this fleet for the period 1969 (FAO, 1976a and 1979), which does not necessarily indicate that the stock has not suffered from the exploitation; improved efficiency of the fleet could very easily mask a decline in the size of the stock. The drop in Ivory Coast catches after 1972, and especially in 1976, correspond, in fact, to a dropping-off in the activity of the fleet in this sector. Horse mackerel and mackerel catches remain secondary. They are essentially the concern of foreign trawlers (especially Ghana, Japan, Poland and USSR).

Some acoustic surveys have been carried out over the continental shelf off Sierra Leone. In 1969 and 1970, important concentrations of *Sardinella aurita* were recognized around the edge of the continental shelf during the months of September and December, and off-shore from Freetown at the beginning of the year (Losse *et al.*, 1971). Thus, between January and May 1970, a biomass of several tens of thousands of tons was recorded North of Sierra Leone (FAO, 1973). Schools of fish have been observed moving northward at this period. More recently, a biomass of 158 000 tons of pelagic fish has been estimated by echo integration off-shore from Sierra Leone (Table 13, Ivanov *et al.*, 1977; *In* FAO, 1979).

Table 12 - Sherbro Division: yearly catches (tons) of pelagic species (Source: FAO, 1979a)

Species	Gear	Country	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Sardinellas (mixed species)	Artisanal fishery	Sierra Leone	2 500	3 000	4 000	4 200	2 000	2 000	17 000	17 000	18 000	22 680	23 040	23 800	24 500
		Liberia	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000
	Trawl	Ghana								3 800	4 770	1 030			
	Trawl and seine	USSR												432	514
	Seine	Ivory Coast				595	-	6 493	8 863	14 793	12 685	16 322	11 683	10 519	7 274
	TOTAL		5 500	6 000	7 000	7 795	5 000	11 493	28 863	38 593	38 455	43 032	37 723	37 751	35 288
Bonga	Artisanal fishery	Sierra Leone	16 500	19 000	23 000	24 000	16 000	18 000	8 000	8 000	12 000	15 120	15 360	15 300	15 300
		Liberia *	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
	Seine	Ivory Coast												393	
	TOTAL		18 500	21 000	25 000	26 000	18 000	20 000	10 000	10 000	14 000	17 120	17 360	17 693	17 300
Horse mackerel (mixed species)	Trawl	Ghana								1 420	1 728			23	
		Japan			25										
		Poland			2	18						1			
	TOTAL		0	0	27	18	0	0	0	1 420	1 728	1	0	23	0
Spanish mackerel	Trawl	Ghana								112	140				
		Poland			206	252									
	TOTAL		0	0	206	252	0	0	0	112	140	0	0	0	0
GENERAL TOTAL			24 000	27 000	32 233	34 065	23 000	31 493	38 863	50 125	54 323	60 153	55 083	54 467	52 588

* Figures reported as clupeids and attributed to the idem bonga

Table 13 - Distribution by main species of the biomass detected off-shore from Sierra Leone (Ivanov *et al.*, 1977; *In* FAO, 1979)

Species	Biomass (tons)
Carangids	66 000
Sardinella spp.	14 200
Balistes capriscus	76 200

The largest biomasses were situated off-shore from Sherbro Island, around the Orontes Bank and North of Freetown. The composition by species, produced from sampling obtained by trawling of the fish detected, shows a predominance of carangids and particularly *Caranx chyrysos*, *C. hippos*, *C. rhonchus*, *Chloroscomborus chrysarus*, *Decapterus punctatus* and *Selar crumenophthalmus*. The sardinella biomass - of which 90% were round sardinellas - is rather weak, but the survey did not cover depths below 20 metres where the flat sardinella and the bonga dominate. The large biomass of trigger fish should also be noticed and this is a species which, to the North, could represent up to 100% of the catches for sweeps over 6 tons/hour. The abundance of trigger fish in this sector is confirmed by an echo survey carried out in November 1978 by the N.O. CAPRICORNE (Marchal *et al.*, 1979). The sudden and not fully understood development of this species had been noted off-shore from Ghana and Ivory Coast (FRU/ORSTOM, 1976 and FAO, 1979), and reported further North off Guinea by Stéquert *et al.* (1977) and Zupanovic and Cissé (1977) (See Chapter III, Section 3.3.2).

These surveys, that are still carried out only occasionally, are not sufficient for us to know if the biomasses observed are stable throughout the year, i.e., they are not sufficient for us to appreciate the importance of exchanges, by seasonal migration, with concentrations in the northern sector. We can only note, by comparing catches and reported biomasses, that if the estimates obtained correspond approximately to the average biomass, any expected growth in the sardinella and horse mackerel catches must be very small.

All these detections only concern a part of the Sierra Leone continental shelf. Unfortunately, we have no information on the biomasses present off the coasts of Liberia. The fact that, apart from the bonga, the sardinellas appear not to be abundant in the two sectors where the superficial layer is of low salinity, warm and present all the year round, as well as the absence of any appreciable fishing off Liberia, particularly by the Ivory Coast sardine fishermen who cross this sector regularly on their way to the fishing grounds of Sierra Leone[1/], makes it improbable that there are appreciable populations of sardinellas off-shore from Liberia.

3.3.2 The Gulf of Guinea (West) Division

In this division, the total catches have practically tripled in thirteen years from 1974 to 1976, going from 35 000 to 97 000 tons. There have been two years when production was very high, one was in 1967 (82 000 tons) and the other was 1972 (162 000 tons). The apparent increase in the catches is partly due to the continuous improvement of Ivory Coast and Ghanaean statistics. The large variations that can be noted are mainly caused by the supplies of round sardinellas. In Ghana, the mackerel and the carangids are regularly caught but in considerably smaller quantities. Since 1973 catches of anchovy have been reasonable.

[1/] The abundance of hard bottom off Liberia is another factor that could explain why there is little seine fishing in this area

The flat sardinella is abundant to the West of the division between Abidjan and Cape Palmas and also the East, between Accra and Benin. Catches of this species have tripled between 1966 and 1976. This increase is mainly due to Ghana where the catch has increased four times in five years, while catches on the Ivory Coast have remained stable since 1966 at around an average 9 000 tons per year. The Ivory Coast boats mostly fish the "Western stock", while the Ghanaeans fish the "Eastern stock". The growth in Ghanaean catches of the flat sardinella coincides with the collapse of the round sardinella stock. It could, therefore, be the result of more attention being paid to the former species for fishermen anxious to keep up production. There is one single stock of round sardinella off the coast of Ghana and the coast of the Ivory Coast. Catches (Table 15), have been big since 1970 and they suddenly jumped to around 100 000 tons in 1972, only to collapse just as suddenly (6 000 tons the following year. They remained practically zero until 1975 but increased in 1976 to reach their previous average level in 1977.

The bonga is abundant off the Ivory Coast and probably also Togo. The species is fished particularly by the Ivory Coast artisanal fishery and the increase in the statistics that occurred in 1975 and 1976 is probably the result of including the lagoon production. Ghanaean fishermen also catch the anchovy and according to official statistics the production reached 58 000 tons in 1977. Ghana reported, in 1975, 32 000 tons of "unidentified clupeids". *A pricri,* it would appear that these are neither sardinellas nor bonga but more likely anchovy that have been incorrectly identified in the statistics. Similarly, doubts have been raised on the value of the figure of 58 000 tons for 1977: it seems an overestimate to experts in Ghan fishery. Catches of carangids are poor in the whole division and concern several species among which the *Caranx rhonchus* seems to predominate. Furthermore, there seems to be a single stock of mackerel centred off Cape Three Points. These catches have followed the same evolution as those for the round sardinella going from a maximum in 1971-1972 (Table 14) only to drop off considerably after that.

This division of CECAF is the only one for which there are detailed statistics available on catch and effort, at least for the sardinella stocks, such as to allow for the application of production models. Thus, for the flat sardinella *(Sardinella maderensis)* Marchal (1971a), then Hem (1976), using only the data from the Ivory Coast fleet, calculated that the maximum balanced catch of the stock situated to the West of Abidjan would be close to 10 000 tons. The catches for 1976 (19 700 tons) and 1977 (11 200 tons) reported by Bouberi (1978) would lead us to believe that the stock is at least fully exploited if not overexploited.

In Ghana, where the drop in production of round sardinella has led the Ghanaean fleet to intensify the fishing of the flat sardinella stock found to the East of the country, the necessary elements are not yet available to evaluate the size of this stock and its relations with that of the Ivory Coast.

With the *Sardinella aurita,* starting from the results reported by the fishery between 1965 and 1971, the maximum balanced production has been estimated at 30 000 tons (FAO, 1976a). This is the level at around which catches fluctuated during the eight years prior to 1972 - except in 1965 and 1968, which were years following catches of more than 40 000 tons (Table 15) As a result of good recruitment, favourable climatic conditions and an exceptional availability, the catches of the round sardinella, in 1972, reached a level that was three times higher than the estimated potential. The catches included a great majority of young prespawners. This probably together with a deficiency in the quantity and quality of food available for the larvae during this year, brought about a spectacular collapse in the stock and in the catches starting from 1973. All the data available and capable of being used to interpret this sudden collapse of the stock have been interpreted in great detail (FRU/ORSTOM, 1976; Troadec *et al.,* 1978). It appears that since 1976 the stock is now being reconstituted.

Table 14 - Gulf of Guinea (West) Division: yearly catches (tons) of sardinellas, bonga and mackerel (Source: FAO, 1979)

Species	Fishing country	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Flat sardinella	Ghana							1 406	4 191	5 263	10 906	16 111	19 428	18 715
	Ivory Coast			9 757	9 849	12 658	6 388	5 845	10 542	14 335	7 328	8 080		10 111
	Togo				1	3	2	2		1	2			
	TOTAL			9 757	9 850	12 661	6 390	7 253	14 733	19 599	18 146	24 191	19 428	28 826
Round sardinella	Ghana							20 566	42 268	88 730	4 700	1 408	2 142	13 799
	Ivory Coast			5 579	11 022	4 433	7 115	10 957	10 181	13 073	866	38	8 779	1 742
	TOTAL			5 579	11 022	4 433	7 115	31 523	52 449	101 803	5 566	1 446	10 921	15 541
Sardinella spp.	Ghana	30 822	3 700	9 446	42 610	21 357	25 966				828	1 459		8
	Ivory Coast			2 000	2 461	2 578	1 698	1 552	2 075	3 824	1 628	1 666		
	Togo	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	2 305	2 305
	TOTAL	33 822	6 700	14 446	48 071	26 935	30 664	4 552	5 075	6 824	5 456	6 125	2 305	2 313
TOTAL SARDINELLAS		33 822	6 700	29 782	68 943	44 029	44 169	43 328	72 257	128 226	29 168	31 762	32 654	46 680
Bonga	Ghana												387	124
	Ivory Coast			1 500	1 846	1 934	1 274	1 164	1 556	2 868	1 221	1 249	7 000	14 000
	TOTAL			1 500	1 846	1 934	1 274	1 164	1 556	2 868	1 221	1 249	7 387	14 124
Unidentified clupeids	Ghana										4 039	2 551	32 356	329
	Togo												1 661	1 661
	TOTAL										4 039	2 551	34 017	1 990
Spanish mackerel	Ghana						4 289	4 782	12 264	15 438	2 003	485	860	93
	Ivory Coast				4 109	581	1 229	2 651	9 404	5 136	238	59		
	Togo												117	117
	TOTAL				4 109	581	5 518	7 433	21 668	20 574	2 241	544	977	210

Table 15 - Round Sardinella. Total yearly catch (tons) for Ghana and Ivory Coast (Source: FRU/ORSTOM, 1976)

Gear	Canoes (Ghana)	Seiners		Total
		Ghanaeans	Ivory Coasters	
1963	5 500	1 960	500	7 960
1964	22 250	7 180	10 900	40 330
1965	2 350	1 550	4 300	8 200
1966	4 200	5 800	5 774	15 774
1967	25 200	11 000	10 930	47 130
1968	2 500	1 800	3 941	8 241
1969	15 900	6 600	7 304	29 804
1970	14 700	4 800	10 911	30 411
1971	27 490	3 724	4 614	35 830
1972	72 350	14 716	7 676	94 742
1973	4 701	615	502	5 818
1974	1 409	260	29	1 698
1975	1 930	131	0	2 061

N.B. These statistics differ considerably from those of CECAF (Table 14) but should be more trustworthy

The mackerel shows a parallel evolution to that of the round sardinella. While it is estimated by echo integration that the stock potential could be around 50 000 tons (Villegas, 1972), catches have remained very low since 1974. The increased interest of Ivory Coast and Ghanaean fishermen for the more in-shore stocks, such as the flat sardinella, following on the collapse of the round sardinella stock, does not entirely explain this drop in supply. It could be that the potential of the stock is considerably lower than what has been thought.

The general distribution of pelagic fish stocks in the division has been confirmed by several acoustic surveys carried out between 1973 and 1977. The average total biomass of the continental shelf off the Ivory Coast and Ghana can be estimated at 250 000 tons; it shows great stability (Marchal and Picaut, 1978). On the other hand, the area to the East of Cape Three Points is three times richer than that situated to the West. However, it has not been able to separate this biomass into its constituent species. It seems however that, as is the case in Ghana and Guinea Bissau, the biomass of trigger fish has considerably increased since 1970 and that it is now the predominating species.

In conclusion, a brutal overexploitation of the round sardinella - the possibility of the same for the mackerel cannot be excluded - apparently helped by abnormal conditions, brought about the temporary quasi-extinction of this stock. Ivory Coast concentrations of the flat sardinella would seem to be fully exploited. While the potential of those stocks to the East of Ghana is not known, it seems unlikely that it could be much greater than the actual catches, at least by comparison with the potentiality of similar sectors (Ivory Coast, for example) and bearing in mind the serious deficit in supplies following on the collapse of the round sardinella stock. A specialized fishery in *Caranx hippos* developed in Ghana during the sixties (several thousand tons). It has since disappeared for reasons that have not been ascertained. The potential of other carangid stocks and that for the anchovy are not known but, with the possible exception of the horse mackerel, it would seem improbable that, overall, the actual level of production could be increased to any great extent. The fairly intense investigations that have been carried out in this area leave little hope of new resources being discovered.

3.3.3 Gulf of Guinea (Centre) Division

The available statistical data for this division are not numerous. The clupeids predominate in the pelagic production which has gone from 36 000 tons in 1964 to 78 000 tons in 1976 (Attachment 5). The increase in catches in 1970 and 1971 correspond to a change in the statistical system used by Nigeria. The system was changed again in 1972. The new figures correspond better to what is now known on the productivity of the division.

Species are poorly identified in the national statistics. It is known that the artisanal fishery, which is important in Nigeria, catches flat sardinellas to the West of the country and bonga off the delta of the Niger and to the East (Bayagbona, 1974). Considerable quantities of carangids began to appear in the catches from 1972, but the various species are poorly identified.

We have no information on pelagic fishery in Cameroon and Equatorial Guinea. It is probably of little importance and should mainly concern the bonga and then the flat sardinella. An attempt to develop a fishery with medium sized sardine boats, according to the methods used in the Congo and using people who had carried out this fishery in that country, collapsed about ten years ago in Cameroon. This is an indication of the weakness in pelagic resources, particularly the sardinella, which could have been foreseen in the light of the poor general productivity of the division. This has been confirmed by the echo survey campaign of the FIOLENT (Table 16) that indicated the total biomass of pelagic fish and demersal fish on the Nigerian and Cameroon coasts to be poor in absolute value as well as in relative value (density). Unfortunately, too few control fishings were carried out for the specific composition of the biomass to be determined.

It sould be noted however that, as in the case of other surveys of this type, the FIOLENT could not operate in the coastal strip. There may be concentrations of fish, particularly bonga, that could be of considerable local importance in these waters as well as in the estuaries and coastal lagoons, at least if the supply of terrigenous nutrient salts is sufficient to counter-balance the poverty of the local oceanic productivity.

3.4 The Southern Sub-tropical Zone

Only the northern part (Gulf of Guinea (South) Division) of this sector is situated in the CECAF region. Nevertheless, because of its hydrography and its stocks - fish in particular - this division is part of a vaster geographic ensemble which goes from the Equator to Cape Frio (17°S). It corresponds to the oscillating zone of the southern inter-tropical front. For this reason it has great similarities with its counterpart in the northern hemisphere (20°N-10°N) to which, in many ways, it forms a symetrical counterpart.

From Cape Lopez (Gabon) to the outlet of the Congo, the catches of pelagic fish are modest (Attachment 6). This sector is only fished by Pointe-Noire sardine boats and an artisanal fishery, which is particularly active in the Congo. Since 1972, the pelagic supplies of the sardine boat fleet vary between 5 000 and 7 000 tons (Tables 17 and 18). To this should be added some 5 000 to 7 000 tons fished by the artisanal fishery (Cayré and Fontana, 1977). The slight importance of the landings is mostly due to there being a limited internal market and to distribution difficulties which prevent the fish from being sold all over the Congolese territory. The two species of sardinella provide most of the supply to Pointe-Noire (Bouchereau, 1976) and represent four fifths of the canoe catches. The actual catches of the Congolese fishery have not had an appreciable effect on the size of stocks, the mass of which is found concentrated off the Angolan coast (Table 18 and Ghéno, 1975). The yearly variation in the yields of the sardine boats from Pointe-Noire, as for the canoe fisheries of Congo and Gabon, mainly reflect external variations of abundance in the sardinella population which result from fluctuations in recruitment or in the size of catches in Angola. The latter have been poor from 1974 to 1976 but they are certain to grow again quite considerably. As regards the effect of the Angolan fishery on its Congolese counterpart, it is to be noted that the latter bears mainly on the young coming from local nursery areas. The impact of the Angolan fishery should, therefore, depend above all on the shape and variability of stock/recruitment ratios. In any case, it would be expected that the effects on the Congolese fishery of the Angolan catches, which affect the adult strata, should be delayed and greatly cushioned.

Table 16 - General results of the FIOLENT acoustic survey (Source: Robertson, 1977)

Country	Surface of continental shelf (20-1 000 m) miles^2	Total biomass of fish (tons)
GHANA (20-200 m)	4 500	464 300
NIGERIA	15 600	136 600
CAMEROON	2 500	22 400

The populations of flat and round sardinellas that are found off the coasts of Angola were exploited up until 1973 by a large fleet of seiners from Angola. The same was true for the Cunene horse mackerel *(Trachurus trecae)* and the pilchard *(Sardinops sp.)*. De Campos Rosado (1974) gives the distribution of catches and species of this fishery between 6° and 20°S:

- from 6° to 10°S: catches are poor (about 10% of the total catch). The two species of sardinellas represent three quarters of the supply, the black horse mackerel has not been reported;

- from 10° to 15°S: 30% to 40% of the total catch comes from this sector. The sardinellas, especially the round species, represent, depending on the year, from 50% to 70% of the supply, and the Cunene horse mackerel from 5% to 25%;

- from 15° to 20°S: this sector accounts for half of the supply. Catches include 60% of horse mackerel and 20% of pilchard. The sardinellas vanish from the statistics, but it is probably that a small percentage of *Sardinella aurita* is included in the pilchard catch.

Except for the catch statistics relating to the Angolan fishery, the necessary data for a stock evaluation which we have available on the Angola portion of these stocks are extremely fragmentary. Even the figures on catches must be created with caution whether they are referring to the total volume of annual landings or its breakdown by species. The standardized catch per tons of the fleet of seiners registered in the ICSEAF 1.2 division (10°-15°S), where most of the sardinellas are caught, seems relatively stable when it is related to the total estimate effort by dividing the total catches by this cpue (ICSEAF, 1976a and 1976b). This observation cannot be taken as proof of the absence of any effect of the fishery on the stock, in view of the numerous sources of bias that are possible (particularly the probable gains in efficiency of the fleet). A comparison with the counterpart area of oscillation of the northern inter-tropical front (where the greatest richness of sardinellas is found), suggests that catches in this sector between South Gabon and South of Angola should be capable of exceeding the total of 150 000 tons landed at the beginning of the seventies (Table 19). The surveys of the FIOLENT (Robertson, 1977), confirm the richness of this sector. It is, however, not possible, with the disparate data that are available, to fix a ceiling, even approximately, on maximum development. As the sardinella stocks - especially the round sardinella - are spread out off several coastal countries, it is even more impossible to determine the portion belonging to each. Such a distribution will have to be negotiated on the basis of much more detailed information on the potentials of the stock and the average distribution of biomasses and their main constituents (juveniles, breeders, etc.) in the various national sectors.

Table 17 – Gulf of Guinea (South) Division: yearly catch (tons) by Pointe-Noire sardine boats (from Bouchereau, 1976)

Year	Sardinellas	Small pelagics	Total of surface fish
1964	1 695	62	1 777
1965	1 826	99	1 925
1966	1 342	74	1 416
1967	1 633	199	1 562
1968	1 641	127	1 768
1969	2 284	137	2 421
1970	3 067	127	3 184
1971	2 420	228	2 648
1972	6 956	45	7 001
1973	6 110	66	6 176
1974	6 342	257	6 599
1975	4 928	214	5 142

Table 18 – Gulf of Guinea (South) Division: Sardinella catches (tons), effort and cpue (tons per day at sea) of a Pointe-Noire sardine boat (from Bouchereau, 1976)

Year	No. of days at sea	Round sardinella		Flat sardinella		Total sardinellas	
		Catch	cpue	Catch	cpue	Total catch	cpue
1964	184.6	592	3.2	1 104	6.0	1 695	9.2
1965	177.4	846	4.8	980	5.5	1 827	10.3
1966	161.8	664	4.1	678	4.2	1 342	8.3
1967	176.8	186	1.1	1 447	8.2	1 633	9.2
1968	150.4	309	2.1	1 332	8.9	1 641	10.9
1969	141.9	1 836	6.7	947	6.3	889	12.9
1970	191.0	1 076	5.6	1 259	6.6	2 335	12.2
1971	351.7	1 017	2.9	1 403	4.0	2 420	6.9
1972	222.3	3 621	16.3	1 015	4.6	4 636	19.8
1973	186.9	3 286	17.3	690	3.7	3 927	21.0
1974	270.5	2 879	10.6	1 861	6.9	4 741	17.5
1975	359.7	542	1.5	3 585	10.0	4 127	11.5

Table 19 – Southern sub-tropical zone: Annual catches (thousands of tons) of sardinellas

Years	Sardinellas		
	Angola*	Congo**	Total
1956	65		65
1957	87		87
1958	50		50
1959	38		38
1960	33		33
1961	52		52
1962	57		57
1963	46		46
1964	86	3	89
1965	43	3	46
1966	54	2	56
1967	45	3	48
1968	79	3	82
1969	156	3	159
1970	67	5	72
1971	86	4	92
1972	142	9	151
1973	116	10	126
1974	50	7	57
1975	21	5	26
1976	20	6	26
1977	135	5	140

* According to Newman (1977)

** According to Bouchereau (1976), artisanal fishery not included (5 000-7 000 tons each year)

4. CONCLUSIONS ON THE PROSPECTS FOR EXPANSION

Prospects for development derive directly from an examination of the state of stocks and their potential. These conclusions are summarized in Table 20. Before looking at each of the three large areas (the northern and southern inter-tropical zones, and the Gulf of Guinea at the centre) that have been considered in this study, some observations of a general nature are necessary.

Although we are getting close to an order of magnitude of the available stocks, which should at least allow, in the first instance, for the establishment of prospectives and the limits of their commercial development, the assessments themselves are still too approximate and certainly not precise enough for the practical requirements of management. From this point of view, the situation differs slightly depending on the sector. In the northern sub-tropical zone, the essential reason for this situation lies in the multispecies nature of the fishery. It is the main cause of what are very likely substantial errors which, in turn, affect the breakdown of the catch by species and, on the other hand, the estimate of the fishery effort effectively applied to each individual stock. In the Gulf of Guinea, and everywhere that the artisanal fisheries are important (Nigeria, Senegal, for example), there is the added difficulty inherent to the collection of statistics in widely dispersed and diversified fisheries. In the Congo-Angola sector, the gathering of data and the work of assessment is still at the initial stages, at least if we refer to the stocks as a whole. The precise assessment of their potential is not yet of extreme urgency, but it is important to ensure that study and surveillance programmes on the state of stocks proceed in parallel with the expansion of the fisheries.

4.1 Northern Sub-tropical Zone

A certain number of remarks can be based on Table 20. The first is that the assessment by Elwertowski *et al.* (1972) (1.5 million tons in total, without the sardine), if they come within the range of the results given here (1.0 to 1.5-1.8 million tons without the sardine), they fall in the upper half. This difference is, perhaps, not only due to the impreciseness of the two series of assessments. The Analysis of Elwertowski *et al.* *(op.cit.)* is based on data prior to the development of the sardine fishery in the Sahara (littoral) division, probably subsequent to the natural expansion of the stock in the Senegalese-Mauritanian sector. If, as is supposed, this expansion originated from a long-term cooling of the hydroclimate, it is possible to wonder if this change in environmental conditions did not also affect, but in the contrary sense, the more tropical type stocks, such as the sardinellas or the horse mackerel *Trachurus trecae* living in the same sector. Their potential would then actually be less than what it was some years ago. Although this is only a hypothesis which has to be proved, it is known that, in most of the pelagic fisheries where information has been gathered over sufficiently long periods, a great variability in the long term seems to be the rule.

This would mean that the total potential of the four groups of stocks - sardine, sardinella, horse mackerel and mackerel - could be less than the total of the potentials calculated by Elwertowski *et al.* for the first three and could be greater for the sardine stock, (probably not far from recent catches (1977)). With a total catch of 1.35 million tons in 1976, the coastal pelagic stocks of the Mauritanian sector would, therefore, already be exploited to such an extent that a second expansion in the catches, as spectacular as that which occurredat the beginning of the decade, would seem very unlikely. This conclusion, of course, applies first of all to the mackerel stock, which seems overexploited, but also to the horse mackerel stocks. For several years the catches of the latter would seem to be not very far off the maximum sustainable yield for the stock. The sardinella stock presently seems the one which offers the best prospects. Nevertheless, recent history of the fishery has clearly shown that important transfers of effort could intervene very quickly (the sardinella catches were in any case nearly three times higher in 1970/72 than they are now). Without control, a brusque intensification in the off-shore fishery for sardinellas is therefore still possible. Furthermore, it should be recalled that the intensification of fishery effort on the part of local fleets is felt especially by the young classes. This new method of exploitation of the cohorts seems less rational than that which prevailed until recently when the off-shore fleets were responsible for most of the catches and concentrated on the older classes.

Table 20 – The state of exploitation of the main pelagic stocks from Mauritania to Angola

Zones	CECAF Division	Stocks	Many types of fishery	Yearly catch (.000 t)			Catch potentials[1] (.000 t)	Level of exploitation (1976)
				1965	1971	1976		
Northern sub-tropical	Sahara littoral and Cap Verde littoral (26°N-9°N)	Sardine	Large-scale fishery	-	124	654[2]	≃ 500 (?)[3]	Seems fully exploited
		Round and flat sardinellas	Large-scale and inshore fishery	38	312	140[2]	350 - 400/600	Probably moderate
		Horse mackerel	Large-scale fishery	62	501	424	450	Probably fully exploited
		Mackerel	Large-scale fishery	28	222	132	200	Seems overexploited
		TOTAL		130	1160	1350	1 000-1 500/1 800 without sardine; could be < 2 000 with sardines	
Gulf of Guinea *(sensu stricto)*	Sherbro (9°N-8°W)	Sardinellas, bonga	Artisanal fishery Artisanal fishery	6 21	39 10	33 17	Unknown but > 50	Unknown Unknown
	Gulf of Guinea (West) (8°W-3°E)	Flat sardinellas	Coastal fishery	?	15	28	10 (West stock) ? (East stock)	Fully exploited
		Round sardinellas	Coastal fishery	8	52	16	30 (Average in the 60s)	Overexploited in 72-75 Now seems reconstituted
		Mackerel	Coastal fishery		22	0,2	< 50	Perhaps overexploited and potential underestimated
	Gulf of Guinea (Centre) (3°E-0°)	Bonga Flat sardinellas	Artisanal fishery	38	130[4]	41	Unknown but small	Unknown
		TOTAL		62	268[4]	135	100 - 200 (?)	

(continued)

Table 20 (continued)

Zones	CECAF Divisions	Stocks	Many types of fishery	Yearly catch (.000 t)			Catch potentials 1/ (.000 t)	Level of exploitation (1976)
				1965	1971	1976		
Southern sub-tropical	Gulf of Guinea (South) and	Flat sardinella Round sardinella	Coastal fishery Coastal fishery Coastal and large-scale fishery	46	92	26	Unknown, perhaps a few hundred 5/	Exploitation low to moderate
	ICSEAF 1.1+1.2+1.3 (0° - 16°S)	Horse mackerel Mackerel	(N.B.: Stocks mainly located off-shore from Angola)					

1/ See explanations in the text

2/ Figures uncertain, but the sum of the two more dependable

3/ From the report by the 2nd CECAF special working party on the sardine, Casablanca (10-23 March 1979) and Dakar (19-22 April 1979) (in preparation) and provided that the concentrations in this sector constitute a separate stock

4/ Value probably considerably overestimated

5/ No assessment available; estimate based on a comparison with the similar stocks in the corresponding Mauritanian-Guinea zone

The coastal pelagic resources of the northern sub-tropical zone are not limited to the four species examined in this chapter. In fact, there are coastal populations of bonga, carangids *(Caranx, Vomer, Chloroscombrus,* etc.), pomadasids *(Brachydeuterus auritus)* that are little exploited or not fished at all. Furthermore, in the cold season, concentrations of young round and flat sardinellas could also be exploited South of Senegal and off the coast of Guinea Bissau, on the shelf of Geba. Most of these populations are not accessible to the large-scale fisheries because of their very littoral distribution. Bearing in mind their restricted extension, it can be thought that their size cannot be compared to that of the big off-shore stocks which have just been studied. Although they are still unknown, their potential should be around several tens of thousands of tons for the entire Cape Verde (littoral) division. It cannot be expected, therefore, that bringing them into commercial use would lead to a large increase in the current total catch. Nevertheless, their importance for the local economies is far from being negligible. They could be exploited with small sized boats (seiners or trawlers). This is the development that can already be seen in Gambia and southern Senegal. It could, in fact, be of possible interest to the whole coastal stretch, from Cape Verde to Guinea.

Among all the pelagic species, two seem to be largely underexploited or underutilized. These are the blue fish *(Pomatomus saltator)* and the grunt *(Brachydeuterus auritus).* As regards the first, usually classed among the great coastal pelagic fish, we cannot, however, expect any substantial development in supply (Champagnat, personal communication). The second which is demersal by its taxonomic status and ecology, can nevertheless be caught seasonally, and in rather important quantities, in the seine and in the mid-water trawl. Small in size, they are taken as a by-catch by the trawlers but are discarded in Senegal where, although they are abundant, they are for the moment without any economic interest. In October-November 1974, during the acoustic surveys mentioned previously, the biomass of this species in the Cape Verde (littoral) division was estimated at 170 000 tons. Bearing in mind the current landings and discards, Domain (Chapter III) assessed its potential at aroun 50 000 tons.

This balance sheet of the potential and the state of pelagic stocks is very approximativ mainly because of the poor quality of the data and it is to be feared that the situation will not improve very quickly. The heterogeneous nature of the fishery, whether it is a question of the nature of the fleets, the mobility of their operations, the variety of legal framework within which they operate, all constitute considerable obstacles to the setting up of an efficient system to collect the most essential statistical data. The use of analytical models, particularly the technique of analysing the cohorts which has to be used to relieve the bias which affects the measurement of effort (and, consequently, the assessment of mortality by the fishery and the abundance of the stock), will not be any easier since it too depends on routine biological sampling that is difficult to set up in a fishery that is so complex and fluctuating. While making every effort to improve, as quickly as possible, the statistical systems that already exist at the national and regional level, every effort must now be made to increase the number of acoustic surveys so as to be able to complete the stock assessments and to follow up their exploitation. These acoustic surveys must cover the entire area of distribution of the main stocks (that is to say from 26° to 10°N approximately and the surveys must include a sufficient number of fishing operations to correctly identify the specific nature of the echos. Although this is a costly method, both in research ship time and in its material and human requirements, it seems to be the only possible way of achieving, in the short term, that accuracy concerning the state of the stocks that is indispensible for their good exploitation.

4.2 The Gulf of Guinea

Except for the area off the Ivory Coast and Ghana, available data are insufficient to calculate the potential of the various pelagic stocks in the Gulf of Guinea. Nevertheless, the information on biomasses, catches, the distribution of fishing operations and on the hydrography of the region allows us to discern, albeit a little subjectively, the potentialities of this sector. Stocks are modest here in comparison to the potentials of the two zones bordering on the North and South of the Gulf of Guinea. This is particularly true for those sectors without upwelling: the two areas where no other activity except artisanal fishing has developed. Stocks already seem to be intensively fished more or less everywhere and the example of the round sardinella stock in Ghana-Ivory Coast shows that, in conjunction with certain natural anomalies, an artisanal fishery is quite capable of overexploiting a stock to such a point as to make it momentarily lose all economic value.

Only the coasts of Sierra Leone seem to offer reasonable prospects for expansion - probably with the off-shore stocks of round sardinella, horse mackerel and mackerel. Although their potential is still unknown, the available information justifies the initiation of pre-investment studies. Elsewhere prospects for expansion seem poor, if not non-existent. Some small stocks (small coastal carangids, anchovy, etc.) could doubtless be more productive but it should be possible to get such results by using the existing catch capacity, simply through a better redistribution of activities. One species, the Cunene horse mackerel *(Trachurus trecae)*, which is one of the major components of the pelagic biomass along the edge of the continental shelf from Sierra Leone to Gabon (Williams, 1968), is still only exploited occasionally by the coastal countries. Its potential has still to be calculated. Its commercial development will depend on the use of more suitable fishing gear and techniques than those used up to now by the trawlers fishing the deep water fish during the upwelling season in the deeper parts of the continental shelf. Because of its rather poor commercial value it still has not been proven that yields could make its exploitation profitable. Finally, mention should be made of the concentrations of stromateidae *(Paracubiceps)* that are encountered in patches at various points along the coast close by the shelf edge, but never yet in sufficient quantities to justify a specialized exploitation.

4.3 Southern Sub-tropical Zone

In view of the importance of its resources, which are probably comparable to those of the Mauritanian-Ghanaean zone, and because of the moderate level of current catches, this area is the one which offers far and away the best prospects for development. In the previous section, only the sardinella stocks were considered, since they are the only ones of interest to the coastal countries (Gabon, Congo-Zaire) of CECAF. Although the potential of these stocks is still unknown, their exploitation seems capable of being increased quite substantially. It should be noted that this potential increase in value concerns mostly Angola, which is the state off whose coasts the greater part of the stock is found, rather than the countries situated between the mouth of the Congo and Cape Lopez. Off the coast of Angola there are also stocks of black horse mackerel *(Trachurus trecae* and *T. trachurus)* as well as mackerel *(Scomber japonicus)* that in size, distribution and the catches they have already provided, are comparable to their counterparts in the northern sub-tropical zone. But as they are centred off the southern coast of Angola, they are only of marginal interest to the countries of CECAF. This is the reason why they have been voluntarily excluded from this inventory. It would be opportune to carry out acoustic surveys as soon as possible, of all these stocks whose potential is very poorly appreciated, covering their entire area of distribution, so as to identify, even in an approximate way, what prospects they offer for expansion and to calculate the investments needed to fully exploit them.

4.4 New Resources

In view of the fact that the exploitation of the pelagic resources in the region being studied here has been going on for quite some considerable time and that numerous surveys and searches have been carried out, it would seem most unlikely that there could exist any appreciable stocks, other than those that have been reviewed, which could be immediately exploited. This, of course, does not apply to species whose commercial interest is still potential, and here we should mention the myctophidae which have been reported in very heavy concentrations off-shore from the Sahara. Gjøsaeter and Glindheim (1978), using acoustical methods, estimated the biomass of these fish at 20 million tons in November 1972 between 16°N and 27°N. Even if this figure seems exceptionally high, this information is important for the future of the fisheries in the area.

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ATTACHMENT 1

Total pelagic catch ('000 tons) between Mauritania (26°N) and the Congo River (6°S)

Fishing areas	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Northern sub-tropical zone (26°N-9°N)	170	133	151	230	370	619	1 139	1 183	1 182	1 194	1 259	1 391	1 439
Sherbro division	24	27	32	34	23	31	39	50	54	60	55	56	53
Gulf of Guinea (West) Division	35	8	32	82	56	54	54	103	162	54	81	80	97
Gulf of Guinea (Centre) Division	36	38	41	46	47	38	139	151	71	74	75	75	78
Gulf of Guinea (South) Division	3	3	2	3	3	3	5	4	9	10	7	5	6
TOTAL	268	209	258	395	499	745	1 376	1 491	1 478	1 392	1 477	1 607	1 673

ATTACHMENT 2

Northern sub-tropical zone ($26^{o}N-9^{o}N$): Total pelagic catch ('000 tons)

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Sardinellas	36	38	44	39	70	83	364	312	378	323	221	297	211
Sardine	-	-	-	-	-	80	89	124	94	189	375	477	653
Carangids	61	62	45	113	169	251	415	501	484	517	488	426	424
Mackerel	66	28	40	68	113	188	247	222	196	134	127	161	132
Pomatomids	7	5	22	10	18	14	20	17	17	15	30	15	13
Various pelagic fish		x				3	4	7	13	16	18	15	6
TOTAL	170	133	151	230	370	619	1 139	1 183	1 182	1 194	1 259	1 391	1 439

x Catches less than 500 tons

ATTACHMENT 3

Sherbro Division: Total pelagic catch ('000 tons)

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Clupeids	24	27	32	34	23	31	39	49	52	60	55	55	53
Carangids	x	x	x	x		x		1	2	x	x	x	x
Mackerel	x		x	x		x		x	x	x			
TOTAL	24	27	32	34	23	31	39	50	54	60	55	55	53

x Catches less than 500 tons

ATTACHMENT 4

Gulf of Guinea (West) Division: Total pelagic catch ('000 tons)

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Clupeids	34	7	31	71	46	45	44	74	131	34	36	74	63
Engraulidae	1	-	1	1	1	1	1	1	1	16	34	-	29
Carangids	-	x	-	6	8	2	2	6	9	2	10	5	5
Mackerel		1		4	1	6	7	22	21	2	1	1	x
TOTAL	35	8	32	82	56	54	54	103	162	54	81	80	97

x Catches less than 500 tons

ATTACHMENT 5

Gulf of Guinea (Centre) Division: Total pelagic catches ('000 tons)

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Clupeids	36	38	41	46	47	36	120	130	38	39	40	40	41
Carangids	x	x	x	x	x	1	11	12	22	23	23	23	24
Mackerel							1	2	x	x	x	x	x
Various pelagic fish						1	7	11	12	12	12	12	13
TOTAL	36	38	41	46	47	38	139	151	71	74	75	75	78

x Catches less than 500 tons

ATTACHMENT 6

Gulf of Guinea (South) Division: Total pelagic catch ('000 tons)

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Clupeids	3	3	2	3	3	3	5	4	9	10	7	5	6
Carangids							x	x	x				
Scombrids								x					
TOTAL	3	3	2	3	3	3	5	4	9	10	7	5	6

x Catches less than 500 tons

ATTACHMENT 7

Gulf of Guinea (South) Division and ICSEAF 47.1.1 and 47.1.2
Total catch ('000 tons) of sardinellas

Divisions	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
CECAF 34.3.6[1]	3	3	2	3	3	3	5	4	5	10	7	5	6	5
ICSEAF 1.1	xx	xx	xx	xx	xx	12	26	21	22	21	50	21	20	135
ICSEAF 1.2	86	43	54	45	79	145	42	66	120	95				
TOTAL						160	73	91	147	126	57	26	26	140

[1] Catches of the sardine fleet based at Pointe-Noire only

xx

CHAPTER III

THE DEMERSAL RESOURCES (FISH)

by

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1. DISTRIBUTION OF SPECIES

1.1 Depth Distribution and Populations

There are numerous works that describe the distribution of demersal species on the continental shelf of the Gulf of Guinea, such as: Postel (1955), Longhurst (1963 and 1965), Crosnier (1965), Crosnier and Berrit (1966), Durand (1967), Troadec *et al.* (1969), Domain (1972 and 1976), etc. In 1963-1964 the Guinean trawling survey (GTS) carried out a systematic survey of the demersal resources from Senegal to Angola (Williams, 1968). This homogeneous collection of data bearing on the sector studied here has enabled Fager and Longhurst (1968) and Longhurst (1969) to isolate, in a detailed and objective way, the various assemblies of demersal fish in the tropical zone and their relationships. Williams *(op.cit.)* has identified the ecological facies to which these various communities correspond.

The distribution of demersal species on the bottom depends on the nature of the sedimentary covering and the hydrographic conditions which determine, on the continental shelf of the Gulf of Guinea, the presence of two large groups of demersal communities:

- those living between the littoral and the bottom of the thermocline (-40 m approx.). They correspond to the zones where the warm and low saline superficial layer is present or oscillates. The most characteristic community is that of the croakers *(Pseudotolithus senegalensis, P. typus, Galeoides decadactylus, Pteroscion peli, Pentanemus quinquarius,* etc.) which all live on soft bottoms; a variety of these - particularly *Pseudotolithus (Fonticulus) elongatus, Elops* spp., *Polynemus quadrifilis,* etc. - live in the low saline facies (river estuary zones);

- a group of communities which occupy, below the thermocline, the various levels, soft and hard, of the continental shelf and slope. The deep water community of sparids *(Dentex angolensis, Pentheroscion m'bizi, Brotula barbata)* dominate the others: the snapper community, the community in the lower parts of the plateau, the community of the slope, etc.;

- in between these two, in the thermocline area, certain coastal species *(Penaeus duorarum, Brachydeuterus auritus, Balistes capriscus)* and others at the upper limit of their distribution *(Pagellus coupei)* are found simultaneously and in association with a typically eurybathic community. In this area, environmental conditions (temperature and salinity) are, at any given moment, the most varied and contrasted.

1.1.1 The coastal species

Two large groups can be distinguished depending on the nature of the bottom.

1.1.1.1 Species on soft bottoms. The tonguefishes, especially *Cynoglossus canariensis* and *Cynoglossus goreensis,* are characteristic of muddy bottoms or sandy/muddy bottoms. They are the object of an important fishery often associated with the fishery of the large pink shrimp *(Penaeus duorarum)* which occupies much the same biotope. The tonguefishes are particularly abundant between -20 and -50 m.

The West African croakers *(Pseudotolithus)* are characteristic of sandy/muddy bottoms closer to the coast:

- the most abundant species overall, *Pseudotolithus senegalensis* is concentrated between 0 and -30 m;

- *Pseudotolithus typus,* always mixed in with the previous species, prefers, however, the less saline biotopes; for this reason it is more abundant close to river mouths and in more coastal areas in general;

- *Pseudotolithus (Fonticulus) elongatus* prefers surroundings that are even less saline. In fact, commercial concentrations correspond to the great estuaries, in the central and southern part of the Gulf of Guinea (Sierra Leone and the mouth of the Congo, for example) where it can be caught in large quantities in certain seasons.

Other characteristic species of soft coastal bottoms that should be mentioned are *Pteroscion peli* and *Argyrosomus regius* among the croakers, the sea catfishes *(Arius* spp.*)*, the sickle fish *(Drepane africana)*, the small carangid *Vomer setapinnis* and the clupeid *Ilisha africana* (two species abundant near the bottom and thus taken in trawl catches) various polynemids, including *Galeoides decadactylus* and *Pentanemus quinquarius* and pomadasyids *(Pomadasys* spp.*, Brachydeuterus auritus)*. This latter species, the bigeye grunter, has a depth distribution that is much wider, since it can be found down to -100 m. It is a quantitatively important species. Williams (1968) has estimated that, from its total biomass, it quite clearly is the first in rank of all the demersal species on the continental shelf of the Gulf of Guinea. Nevertheless, because of its small size, it is only fished in those sectors (centre of the Gulf of Guinea in particular), where the demand for more sought-after fish is difficult to satisfy during certain seasons.

1.1.1.2 Species on hard or sandy bottoms. The more important species that are encountered among the coastal communities on hard or sandy bottoms include:

- the porgy *(Pagrus erhenbergi)*, which has its maximum abundance between -20 and -30 m. This species lives on sandy or muddy/sandy bottoms. It is mostly present in the area of Cape Verde where it is caught in appreciable quantities by trawlers and the artisanal fleets. Rijavec (1973) studied the *P. erhenbergi* which is of great importance to Ghana on the bottoms off the coast of this country;

- *Epinephelus aeneus:* this grouper is widespread on all the continental shelf from -10 to -100 m approx. It is particularly abundant around -50 m. It is highly appreciated, and is caught both by the trawler fleets and by the artisanal fishery using handlines. This is particularly the case in Senegal.

1.1.2 The deep water species

These live off-shore beyond the thermocline on sandy/muddy bottoms starting at a depth of about -70 m.

Two species of *Dentex* are found in abundance beyond -70 m; these are *Dentex angolensis* and *Dentex macrophthalmus*, which are liable to be caught in great quantities by the industrial fishery. They are fished particularly in the cold season where, with rising yields, they constitute the target species for local trawlers operating on the bottom between 70 and 120 m. On the deep part of the shelf, the sardine *(Paracubiceps ledanoisi)* and the croaker *(Pentheroscion m'bizi)* are two species of secondary commercial interest. They are worth mentioning, however, because of their abundance, as should be *Synogrops microlepis* which is found on the slope and is even less easily used, at least for direct human consumption.

Brotula barbata, lives between -70 and -200 m. This is a species which is beginning to be fished in Senegal and it seems to provide good yields. Further to the South it is considered as being a species of secondary economic interest (Williams, 1968). It is, however, appreciated in Ivory Coast.

Hake *(Merluccius senegalensis* and *cadenati* to the North; *M. polli* in the Gulf of Guinea) are only found in abundance (from -100 to -400 m), in the Cape Verde area to the North, and off-shore from southern Angola. In the Gulf of Guinea proper, yields have up to now always been insufficient to justify, even with the other species of the slope, a specialized exploitation. For several years Spanish trawlers have also been catching, on the slope, the deep water rose shrimp *Parapenaeus longirostris*, mixed in with *Aristeus varidens* and *Plesiopenaeus edwardsianus* (Crosnier and Tanter, 1968). As in the case of hake, these species do not seem to be sufficiently abundant in the Gulf of Guinea and their exploitation has been limited up to now to the two extreme sectors of the gulf and to the areas just outside.

1.2 Geographic Distribution

These various tropical communities occupy the entire Gulf of Guinea and spread even beyond it, in the North, toward the latitude of Cap Blanc (Mauritania) where the Guinean fauna gives way to a fauna more typical of the Saharan sector and of warm temperature areas. It is the same in the South where they spread down to southern latitudes (Cape Frio) of Angola. All the area covered in this section is thus populated by a fauna of homogeneous composition, although several species typical of the Saharan area penetrate in the North into the Senegal-Mauritanian sector, and, in the South, to the southern part of Angola.

Their abundance, however, is not homogeneous. Parallel to the spatial variations of oceanic productivity, acute differences appear in the distribution along the coast of the demersal biomass. Fig. 1 shows yields (inclusive of all demersal species) obtained, from 0 to 50 m on the one hand, and from 50 to 200 m on the other, at each of the 63 transects covered during the GTS campaign. These transects each of which was visited twice, at six-monthly intervals, to take into account seasonal variations, cover the totality of the Gulf of Guinea from Gambia to the mouth of the Congo. Although the phenomena would have been still more evident if the area covered had been extended further South to off the coast of Angola, the by-polarity in the distribution of the demersal biomass, mentioned in the introductory chapter (see page) shows up very clearly. In the oscillating area of the northern and southern intertropical zones (21°N-10°N approx.) and South (0°-17°S approx.) yields are several times superior to the densities obtained in the tropical part of the Gulf of Guinea. Inside the latter, however, a secondary maximum area appears off Ivory Coast and Ghana. It corresponds exactly to the sector influenced by a seasonal upwelling (Gulf of Guinea (West) statistical division, Fig. 3). Between these three sectors, i.e., off Sierra Leone and Liberia on the one hand and from Nigeria to Gabon on the other, the superficial layer, warm and of low salinity, is permanently present. This results in productivity that is, on the average, low.

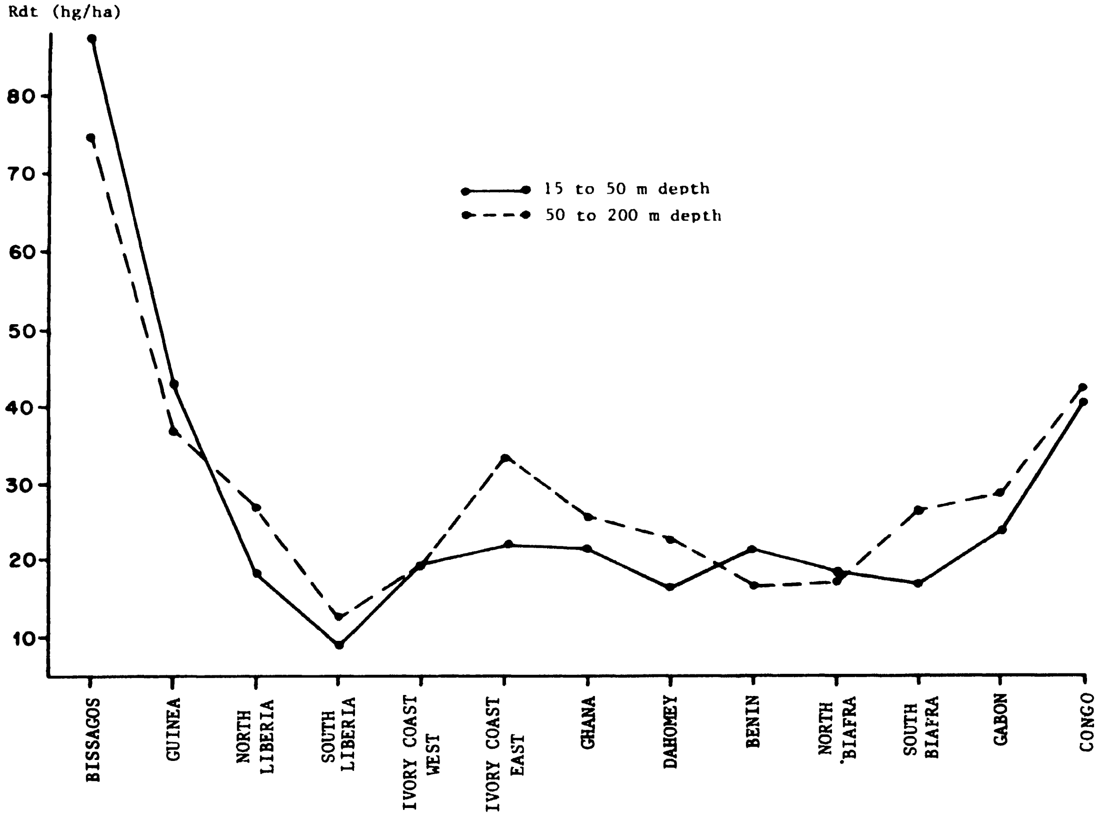


Figure 1 - Variation in biomass of demersal stocks in the Gulf of Guinea (according to the yields obtained during the G.T.S. survey; Williams, 1968).

1.3 Migrations

1.3.1 Migrations parallel to the coast

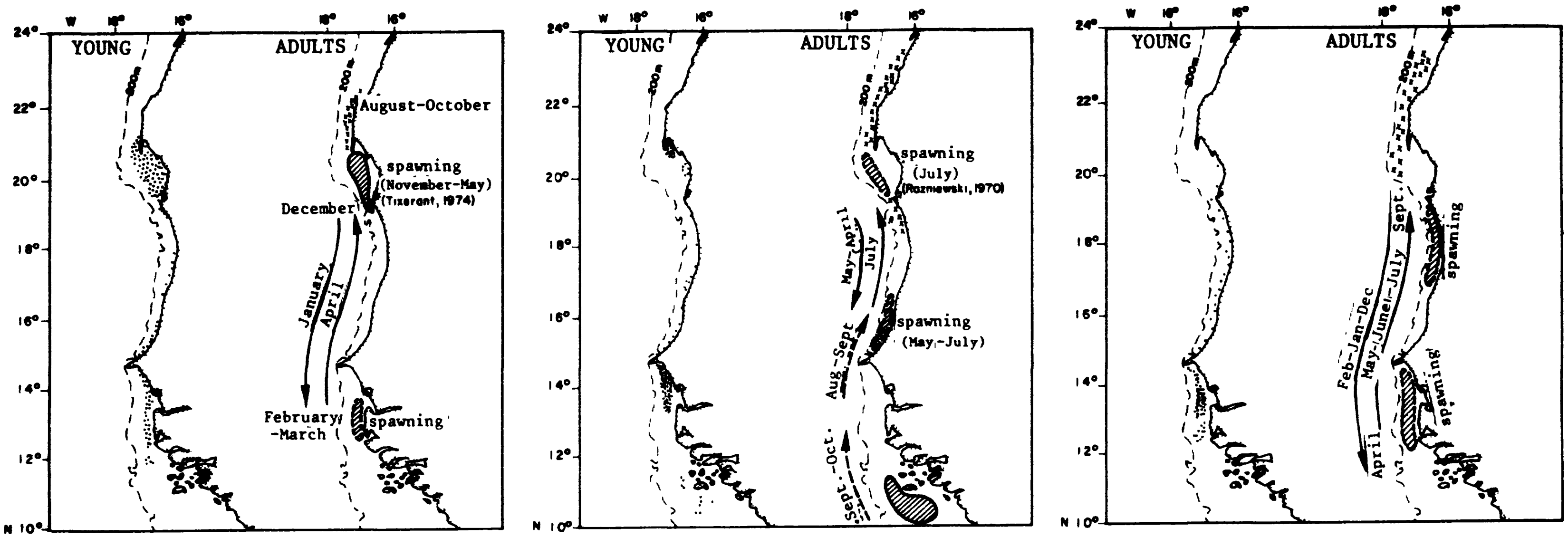
Seasonal movements by fish are the way in which they adapt in order to get the best part of the production cycle of the waters (Harden Jones, 1968). Shifts in the latitude of frontal zones, which are environments of strong primary and secondary productivity, are reflected by shifts of stocks parallel to the coast. Thus we find migrations of considerable distances where the oscillations in latitude of the fronts are very wide, e.g., along the coasts from Mauritania to Guinea. On the other hand, in the central part of the Gulf of Guinea, there is no clear progressive extension of new seasonal conditions, marked by either the advance or withdrawal of a frontal zone along the coast. Either that or the seasonal variations are very slight throughout the entire year: this is the case of the two sectors where the superficial warm layer is permanently present. Or else, as is the case off Ghana and Ivory Coast, the conditions of upwelling rapidly reach their maximum extension over all the sector and then disappear. In fact, nowhere in the tropical zone do the coastal migrations of the demersal species reach a scale that can be compared to those which take place in the sub-tropical peripheral areas.

Champagnat and Domain (1979) have described the migrations of demersal fish from 10° to 24° latitude North in the area of oscillation of the northern intertropical front (Fig. 2). They distinguish between the behaviour of species typical of the Saharan area from the behaviour of Guinean species. Those of the former type gather together from August to October between 20° and 23°N; they then actively feed after reproduction. Starting in November they migrate toward the South following the spreading of the upwelling, to establish themselves between 10° and 16°N in February-March. This is a period of intense feeding and of sexual maturation. In May-June, the return northward starts at the same time that spawning begins. This reaches its maximum point between 19° and 21°N from the end of June to mid-August. The young concentrate in reservations characterized, it seems, by the persistence of sufficient food in the warm season (outlets of rivers on the one hand, and South of Cape Verde, South of Cape Timiris, the Arguin Bank where small local upwellings exist in the warm season on the other hand). They seem to stay there from one to three years until their first spawning. They then rejoin the adults to participate in the migratory cycle.

The less abundant Guinean species migrate less and draw part of the production induced by upwelling in the cold season and very likely of those tied to the discharge of rivers in the warm season. From January to June, the species are concentrated on the coastal fringe, around the mouth of the Senegal, and especially in the estuary complex that stretches from Saloum to Guinea. In June, there is a rapid movement toward the North. The fish spawn between the mouth of the Senegal river and Cape Timiris, and then disperse in this region. They return to the estuary zones starting from December.

This pattern of limited movements in the Guinean species is in keeping with the observations of Troadec (1971). In the central part of the Gulf of Guinea, he found that *Pseudotolithus* and probably most of the warm water species manifest a great tolerance relatively to the conditions of the environment since they support, apparently without much migration along the coast, the arrival of the cold waters which cover their biotope in the period of upwelling and content themselves with a change in depth, the extent of which is less than that of the isotherms. In this same sector, Garcia (1977) reached the same conclusions for the *Penaeus duorarum* shrimp.

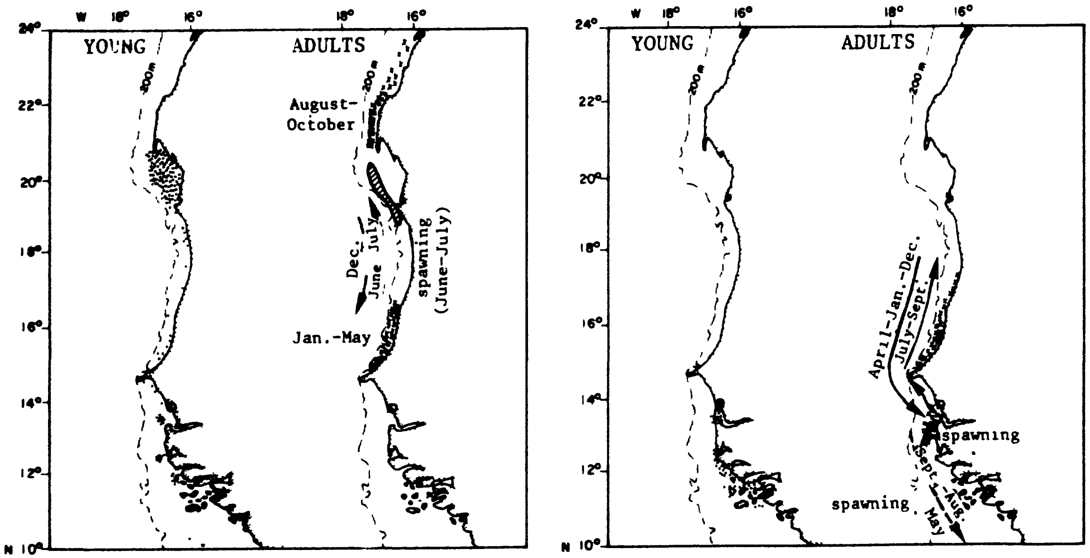
These observations on the extent of geographical migrations have an immediate effect on management. In fact, in the case where movements are limited, any management measures taken unilaterally by the coastal states could be sufficiently effective, at least for those whose coastline is not too small (Troadec, 1971). In the opposite case, the effectiveness of any actions taken concerning management will obviously depend on the harmonization of national policies regarding regulation and control.



Meagre (Argyrosomus regius)

Porgy (Pagrus ehrenbergi)

White grouper (Epinephelus aeneus)



Blue fish (Pomatomus saltatrix)

Grunter (Pomadasys jubelini)

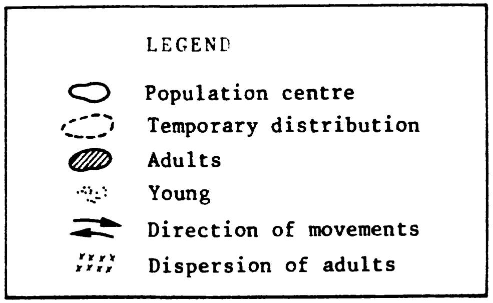


Fig. 2 Examples of distribution and migration patterns for four demersal species and one pelagic species in the Senegalo-Mauritanian sector (from Champagnat and Domain, 1978)

1.3.2 Movements perpendicular to the coast

For coastal species, the thermocline constitutes the limiting frontier for their extension in depth. Its vertical seasonal swings bring about movements perpendicular to the coast. However, the thermocline is not an insurmountable barrier for the coastal species since, as we have seen, in the sectors with seasonal upwelling, these species, after being concentrated on the coast, put up with infrathermoclinal conditions when the superficial layer disappears. The analysis of these movements of species in relation to changes in the environment has been done on the basis of systematic trawling on a transect that has been visited periodically (Durand, 1967; Troadec *et al.*, 1969). In fact, the coastal communities, like the deep water communities,are able to greatly absorb, in their movements perpendicular to the coast, the seasonal shifts of the thermocline and masses of water on the shelf. The study of these phenomena through a programme of systematic trawling is not easy since results can be affected by, for example, variations in availability as a result of changes in the vertical distribution of the fish. Thus, Troadec (1971) has pointed out that the *Pseudotolithus* could, at the end of the upwelling, come between two waters and thus avoid the layer of water that is very poor in oxygen present close to the coast and on the bottom at this time. Similarly, the respective role of a concentration in the cold season of *Dentex angolensis* at depths of between 70 and 120 m and a much greater vulnerability of the species to trawling at this time, still has to be specified in order to explain the sharp growth of its availability at that moment. In fact, at several points in the Gulf of Guinea (Congo for example), the fishing season is limited to this period and to these bottoms. More generally speaking, it is often found that several species group seasonally at the time of reproduction at reserved depths (ISRA/ORSTOM, 1979).

The study of these phenomena is complicated by the fact that the response of species to environmental conditions varies with age. Thus, the young, often concentrated close to the coast before recruitment, gradually move off-shore as they grow bigger. It is for the shrimp *Penaeus duorarum* that studies are most advanced on the role of ecological factors in movements perpendicular to the coast and the behaviour, particularly over 24 hours, of individuals (Garcia, 1977).

2. DISTRIBUTION OF CATCHES IN THE AREA

2.1 Available Data

In the absence of information on the identity and distribution of stocks, it will be more convenient to study their potential and the state of exploitation by following the geographical divisions adopted by CECAF for the compilation of statistics. These divisions have been determined on the basis of the large hydrographical units - sectors with a seasonal upwelling and sectors where the warm superficial layer is permanent - that are relatively homogeneous, and described in the introduction (page 5). Until evidence emerges to the contrary, it is presumed that there is, for each species, a stock per division. There are some exceptions where this hypothesis is not completely satisfactory. For example, the cephalopod resources, which are particularly large in the northern part of the CECAF area, overlap with the Sahara (littoral) and the Cape Verde (littoral) divisions, in practice between 26°N and 13°N. In these cases, it will obviously be natural to analyse the data relating to the two contiguous divisions as a whole.

The areas of the continental shelf, measured on the map by sections of depth and national sectors for each division, are given in Table 1. This information is of interest for two reasons.

First of all, the extent of the shelf constitutes, with the oceanic productivity, an essential factor in the richness in fish of a region. In general, the continental shelf is relatively narrow; its breadth is scarcely more than 30 miles North of Cape Verde and 20 miles in the Gulf of Guinea. There is one exception: the sector of the Bissagos archipelago where the breadth of the shelf is more than 100 miles. The extension of the shelf is going to accentuate the difference already reported in the geographical distribution of the density

Table 1 - Gulf of Guinea: area (km^2) of CECAF statistical divisions

CECAF Divisions	Coastal countries	Surface of continental shelves (km^2)			Total surface (km^2)	Surface of the entire divisions (km^2)
		0-10 m	10-50 m	50-200 m		
Cap Verde (littoral) (CECAF 34.3.1)	Mauritania					123 000 (39%)
	19°N to 17°N		4 800	6 200	11 000	
	17°N to Senegal		2 200	1 800	4 000	
	Senegal	3 600	11 600	8 400	23 600	
	Gambia	1 100	2 600	1 400	5 100	
	Guinea-Bissau	16 300	14 000	6 800	37 100	
	Guinea	5 600	28 700	7 900	42 200	
Sherbro (CECAF 34.3.3)	Sierra Leone	5 000	16 200	6 300	27 500	45 900 (15%)
	Liberia	1 500	5 300	11 600	18 400	
Gulf of Guinea (West) (CECAF 34.3.4)	Ivory Coast		4 700	7 600	12 300	37 100 (12%)
	Ghana		11 700	8 500	20 200	
	Togo		1 100	500	1 600	
	Benin		2 100	900	3 000	
Gulf of Guinea (Centre) (CECAF 34.3.5)	Nigeria	5 100	21 600	14 300	41 000	60 100 (19%)
	Cameroon	3 400	5 700	6 300	15 400	
	Equatorial Guinea		2 000	1 700	3 700	
Gulf of Guinea (South) (CECAF 34.3.6)	Gabon[1/]	3 100	17 000	18 400	38 500	48 800 (15%)
	Congo		3 700	6 600	10 300	

1/ The section of the Gabon continental shelf situated to the North of Cape Lopez belongs to the CECAF division 34.3.5

of demersal populations (Fig. 1): for this reason, we can expect that the potential of the Cape Verde (littoral) division, where the shelf has an area two or three times greater than that of the divisions situated further South in the Gulf of Guinea (Table 1), will be much greater than those of other divisions.

Furthermore, these areas will serve to extrapolate to larger ensembles the evaluations of available stocks, according to the principles which will be discussed in Chapter 3.

Most of the statistics on catches that have been used come from the Statistical Bulletin of CECAF (FAO, 1976 and 1979). These data have certain drawbacks which have already been analysed (Ansa-Emmim and Levi, 1975). Some countries, such as the USSR and Portugal, do not yet report their catch figures broken down by statistical divisions. To estimate their catches by divisions and, thus, the total corresponding catches, recourse has had to be made to approximations based on the ratios of surfaces fished of divisions where the ships of these countries are supposed to operate on a regular basis.

It would also be wiser to be careful in considering the figures published for the Gulf of Guinea (centre) division which appear to be excessive for some species. Very likely this is due to a technicality in the Nigerian statistics where the system of compiling the figures was modified after 1970. Starting from that date, estimates have been established on the basis of assessments founded no longer only on samplings of production but also on an assessment of national consumption. The consumption of fish estimated was far superior to the estimates of production. However, comparison of production by surface units of neighbouring sectors of the continental shelf (Cameroon, Ghana, Togo), indicate that the production of the continental shelf should probably not be more than the values reported before 1970. The new evaluations given in Section 3.3 confirm this observation. One may wonder if the catches realized by foreign ships, chartered by Nigeria and thus working under the Nigerian flag but not fishing off Nigeria in the Gulf of Guinea (centre) division, have not been included under this item by mistake.

2.2 Overall Catches by Division

The data in Table 2, taken from the Statistical Bulletins of CECAF,confirm the great richness of the Cape Verde (littoral) division as compared to the other divisions of the Gulf of Guinea. Before 1970, from which date the Nigerian data - and thus the catches of the Gulf of Guinea (centre) division - are very likely overestimated, the catches in the Cape Verde (littoral) division represent, by themselves alone, between two thirds and three quarters of the total catch identified as demersal. It is likely that this ratio has remained just as high, since demersal fishery has continued to progress in the Cape Verde (littoral) division, while it has tended to stagnate in the others, except for the Gulf of Guinea (West). Such is the case, in particular, of the two divisions which do not benefit from a seasonal upwelling. It must,however, be noted that these statistics are not all exactly comparable. They correspond, in fact, to catches reported as demersal in the data transmitted to CECAF. But it is not known if the relative importance of non-identified catches (as those of demersal species as compared to the latter), has remained stable from one fishery to another and thus from one division to another. For example, it has been noted that the identification of catches by groups of species was particularly bad in the Sherbro division.

Table 3 shows the evolution of total catches for some large groups of species, generally better identified in the statistics, and figuring among the most sought-after. It is particularly the case of the croakers *(Pseudotolithus* in particular*)* the tonguefishes, and the representatives of the coastal community in general, on which the local fleets of trawlers concentrate their operations. The expansion of these catches is very slow, the increase being not more than 200 to 300 per cent on the overall period considered (1964 to 1977). If we remember that the statistical coverage must have improved at the same time and that all countries of the Gulf of Guinea suffer from a deficit of supply, we have here an indication that these stocks offer restricted possibilities for expansion and must be already intensely exploited for several years. Most authors who have studied, in the sixties, the various local trawler fisheries, whose operations were concentrated on the coastal croaker community, arrived at similar conclusions: Sierra Leone (Watts, 1962), Ivory Coast (Fonteneau, 1970, 1971), Nigeria (Longhurst, 1964, 1965; Bayagbona, 1965), Congo (Le Guen, 1972; Troadec, 1971), in particular.

Table 2 – Total yearly catches ('000 tons) of demersal species in the Gulf of Guinea as a whole (19°N to 6°S)

Species	Years										
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Pleuronectiformes	3 107	4 014	3 751	(13 726)	(16 027)	6 558	8 029	8 697	10 712	9 272	10 715
Gadiformes	8 677	9 164	9 081	7 142	11 772	9 347	25 943	30 135	26 185	23 906	11 845
Sparidae	34 558	34 117	41 698	56 798	62 297	70 537	79 357	63 788	71 863	59 685	57 272
Sciaenidae	20 757	26 481	21 854	(54 931)	(68 515)	37 593	48 594	38 497	43 066	45 890	36 801
Pomadasydae	1 155	6 207	11 501	9 544	11 795	25 387	24 838	25 356	25 949	28 492	32 975
Balistidae	0	0	0	0	500	500	519	662	9 442	9 520	10 498
Mullidae	846	587	438	1 033	1 192	1 073	738	768	1 264	1 455	1 805
Trichiuridae	1 968	3 530	4 285	6 475	9 079	13 903	8 919	14 084	10 013	13 220	27 524
Demersal percomorphi	14 315	14 833	15 702	80 555	96 976	82 745	93 480	99 140	92 618	90 928	128 079
Sharks, rays	4 713	5 611	5 829	(36 356)	(41 693)	24 144	28 946	31 508	31 377	29 614	29 763
Shrimp	7 341	17 923	22 362	19 461	21 056	26 715	18 429	22 989	24 310	22 816	25 476
Cephalopods	6 827	7 031	13 350	10 327	16 819	19 491	21 303	26 299	29 034	29 977	22 717
Total identified demersals	104 918	130 518	151 467	298 917	362 335	325 562	366 225	370 976	386 476	377 853	404 316
Unidentified (incl. pelagics)	137 982	134 877	195 939	(220 319)	(230 876)	235 051	189 028	200 930	236 926	178 886	197 207

Source: CECAF Statistical Bulletin No. 2 (FAO, 1979): the figures given refer to the sum of the catches reported in divisions 34.1.3, 34.3.1, 34.3.3, 34.3.4, 34.3.5 and 34.3.6, + 1/3 of the catches reported (Greece, Portugal, USSR) for the group of divisions 34.1.1, 34.1.3 and 34.3.1 + 1/2 of the catches reported (Spain) for the group of divisions 34.3.1 and 34.1.3

( ) = Values probably overestimated

Table 3 - Yearly demersal catches (in '000 tons) (excluding crustaceans and cephalopods) by statistical divisions

Divisions	Years													
	1964[1/]	1965[1/]	1966[1/]	1967[2/]	1968[2/]	1969[2/]	1970[2/]	1971[2/]	1972[2/]	1973[2/]	1974[2/]	1975[2/]	1976[2/]	1977[2/]
Cape Verde (litt.) (A + B + C) 3/	69101	66561	65243	77145	95734	117707	123823	160245	179612	223224	230157	221662	193781	134479
Sherbro[4/]	3351	1365	1461	1670	1428	542	3140	4292	9679	5843	6263	5394	4972	5830
Gulf of Guinea (West)	6110	4483	21865	6041	12252	18477	22889	22866	33754	35308	32783	50885	48791	119040
Gulf of Guinea (Centre)	19824	19995	22013	24144	25607	18246	142437	172864	101776	106305	106532	108431	114717	116520
Gulf of Guinea (South)	-	-	-	7500[5/]	7600[5/]	6700[5/]	4696	2810	5252	3962	5444	6969	4941	7200
TOTAL	98386	92404	110582	116500	142621	161672	296985	363077	330073	374642	381179	393341	367202	383069

Sources: 1/ CECAF Statistical Bulletin No. 1 (FAO, 1976)
2/ CECAF Statistical Bulletin No. 2 (FAO, 1979)

3/ The figures relating to the Cape Verde (littoral) division correspond to the sum of the catches reported for this division + 1/3 the catches reported (Greece, Portugal, USSR) for the group of divisions 34.1.1, 34.1.3 and 34.3.1 + 1/2 of the catches reported (Spain) for the group of divisions 34.3.1 and 34.1.3

4/ Values probably underestimated

5/ Only catches from trawlers based at Pointe-Noire, Congo (Statistics of Ocean Research Centre, Pointe-Noire)

One single species, the bigeye grunter *(Brachydeuterus auritus)*, is outside this development. Its reported catches have increased eighteen times from 1964 to 1976. We have seen that this species, which is small in size, gives a good indication of the deficit in supplies, since it is only commercial when and where landings of more sought-after species cannot satisfy demand. The progressive commercialization of the bigeye grunter is an indication that this deficit in fish must have gradually increased and spread over the Gulf of Guinea as a whole.

3. STATE OF RESOURCES

3.1 Methods of Evaluation

Too frequently, the necessary data to assess demersal stocks in the Gulf of Guinea are either not available or they are too imprecise for it to be possible to try to make assessments using the classic models. Stocks for which sufficiently detailed data are available to be used in analytical models are the exception rather than the rule. Among these, we can mention the assessments of the Congolese croakers, *Pseudotolithus elongatus* (Le Guen, 1971), and *Pseudotolithus senegalensis* (Troadec, 1971), the Ivory Coast pink shrimp stock (Garcia, 1977) and the Congolese demersal stock (Fontana, 1979). Each time that the quality of the data on catch per unit effort allowed it, assessments with the help of a global production model have been attempted. In general, these estimates concern the species of a community overall, such as the coastal community (0-50 m) on soft bottoms, or all those present on a portion of the continental shelf and exploited simultaneously by the same fleet (see for example Fonteneau, 1970).

Assessments of instantaneous biomass are also available, obtained either by trawling (particularly the data from the GTS campaign), or by echo integration. The fact that the rate of exploitation of the stocks at the moment of the surveys is generally not well known makes it a relatively subjective exercise to use the approximate formula of Gulland (1971) in order to pass from the biomass to the maximum potential catch. However, in relation to the rate of exploitation only, the biomass has probably not declined by a factor of more than two or three, it being understood that in 1963-64, at the time of the GTS campaign, no sector was heavily overexploited. The relative density of the demersal biomass in the different sectors varies (again according to the GTS data (Fig. 1)), by a factor of more than 10 and the surface of the shelf in the different divisions by a factor of more than three, the richest sector (Bissagos) also being the one where the shelf is the largest. In spite of the imprecision of the rate of exploitation, the results of the surveys should thus allow for an order of magnitude appreciation of the potential of the different sectors of the Gulf of Guinea.

Finally, when the poverty of data prevents either one or other of these methods from being used, we have proceeded by analogy, by extrapolating to wider groups the available assessments for certain stocks or portions of the continental shelf. The principles of application for this method have been reviewed by Troadec (1977) and a good example of this procedure is given in the section "Pink shrimp resources *(Penaeus duorarum notialis)*". To keep the source of bias to a minimum, extrapolations have been restricted to geographical sectors (statistical divisions) or to communities (0-50 m for example) within which productivity should quite clearly vary less than between the various groups. To the extent that the initial hypotheses on the relative importance of the variability of the productivity within the sectors and between these are correct, this method should allow us to approximately quantify the relative richness of the various portions of the continental shelf in the Gulf of Guinea.

3.2 Cape Verde (littoral) Division

A detailed description of the different fisheries present in this division, (i.e., of the fleets (artisanal, local, semi-industrial and industrial, foreign) and the main fishing grounds and species caught), is given in the report of the *ad hoc* CECAF working group on the demersal coastal stocks between the South of Mauritania and Liberia (FAO, 1979a).

The Cape Verde division appears to be the richest area in the Gulf of Guinea. The data and effort of the Polish trawlers of the 5.5 GRT type between 1964 and 1974 (FAO, 1976) allows us, with the help of a Fox model, to evaluate the annual potential catch of demersal species in the division at 135 000 tons (Attachment 1). A similar procedure, using Japanese data, (from 1964 to 1971 - FAO, 1976), gives an assessment of 154 000 tons (Attachment 2). These two results can be considered in good agreement. The trend of the catches during the last years indicates that this result is possibly underestimated.

The echo integration data allow us to test the validity of these results. A campaign carried out off Senegal in April-May 1976 assessed the demersal biomass at around 400 000 tons (Gerlotto *et al.*, 1976). At this time of the year, the major part of the demersal stock in the Cape Verde (littoral) division is found in the Senegal-Gambian sector. If we admit that the juveniles, often concentrated close to the coast in zones that are inaccessible to trawlers, are either not exploited at all or in a way that is greatly reduced, the biomass of 400 000 tons could be close to that of the exploited stock. Catches are equal to the product of the fishing mortality, by the biomass B:

$$C = F \times B$$

In 1976, total catches realized in the Senegalese waters have been, according to the available statistics, (FAO, 1979) 204 000 tons. This quantity is very close to the average annual catches realized during the four preceding years (1972 to 1975; cephalopods and crustaceans included). We can thus admit that the rate of exploitation and the stock were stabilized in 1976. The fishing mortality F would thus have been close to 200 000/400 000 = 0.5 in 1976. If we consider that the species in the area have a lifespan of around four to five years, the Tanaka scale (*In* Alverson, 1971) gives an assessment of the natural mortality coefficient M equal to 0.5-0.6. The estimates of mortality of the particular species (for example Le Guen, 1971; Troadec, 1971) indicate that at least for the species of larger size, the natural mortality coefficient should be considerably less (in the order of 0.3). In the absence of more precise information, we can admit that the average rate of the natural mortality coefficient for the whole of the demersal species exploited by the trawlers could be in the order of 0.4. F could, therefore, be equal or slightly more than M. This is an indication that, in current conditions of exploitation, the exploited demersal stock off the Senegalese coast should be close to the maximum equilibrium production or perhaps even slightly overexploited for the larger size species which are also in general the most sought after. Bearing in mind the level of precision that can be accorded to these methods, we can admit that the agreement between the results obtained by the three assessments is good.

A control estimate can be obtained on the basis of the GTS data. These have, furthermore, the advantage of permitting the breakdown of potentials by geographical sectors. At the time (1963-64), the fishing grounds of the Casamance - Guinea-Bissau sector covered by the GTS campaign were only slightly exploited. The estimated biomass at the time (average cold season + warm season) can thus be considered as satisfactory for the application of the Gulland formula $C_{max} = 0.5$ MB. For the Casamance - Guinea-Bissau - northern Guinea (13^{o}-10^{o}N) the estimated biomass (Williams, 1968) is 359 000 tons (without catches of pelagic species nor of *Brachydeuterus*). If we still admit that M = 0.4, the potential would be 72 000 tons. By proportional interpolation to the ratio of the respective surfaces of the continental shelf (from 10 to 200 m), the potential of the sector bordering the Guinea-Bissau only would be around:

$$72\ 000 \text{ tons} \times \frac{21\ 000 \text{ km}^2}{37\ 000 \text{ km}^2}, \text{ i.e. } 40\ 000 \text{ tons}$$

The GTS surveys unfortunately stop, in the North, at the level of the Casamance. We do not, therefore, have estimates of the biomass for the parts of the shelf situated off Senegal-Gambia and Mauritania. An attempt can be made to extrapolate the preceding estimate from the potential pertaining to Guinea-Bissau proportionally to the surface of the shelf. For this it would be necessary to bear in mind the probable variations of the average annual density of stocks as one moves North and, thus, of their productivity. Echo integration carried out, in the cold season, from Mauritania to Guinea (Marchal and Boely, 1979) gives the following density ratios (all species included) for the areas of Guinea Bissau, Senegal-Gambia and Mauritania:

$$\frac{\text{Senegal-Gambia}}{\text{Guinea-Bissau}} = 1.14; \quad \frac{\text{Mauritania}}{\text{Senegal-Gambia}} = 0.65$$

If the distribution of the biomass at this season is too different from the average annual distribution and if the density ratios in the various sectors are sufficiently close for the pelagic species and the demersal species, the latter could serve to correct the extrapolations based on the ratios of the shelf areas only. We thus arrive at the following very approximate estimates:

Senegal-Gambia potential: 56 000 tons
South Mauritania (South 19°N) potential: 22 500 tons

If at the time of the survey, the fish were, in relation to the yearly average, concentrated in the southern section (Senegal-Gambia, Guinea-Bissau) - something that would seem probable - these figures would overestimate the potential of the Senegal-Gambia area to the detriment of the southern Mauritanian sector.

Starting with trawls carried out in 1971 and 1972 on the continental shelf between Cape Timiris (19°20'N) and Cape Roxo (12°20'N), Domain (1974) estimated the total demersal biomass at 60 000 tons for the Mauritanian section (Cape Timiris-Senegalese frontier) and that situated off Senegal-Gambia at 208 000 tons. Eighteen per cent of this biomass was made up of non-commercial species. The biomass of commercial species can thus be estimated at 50 000 tons and at 170 000 tons, if we include the *Brachydeuterus auritus*. If we consider that, at that time, the exploitation of stocks in the region was still only average, we can admit (the basis for this reasoning are given in Section 3.3) that the potential represents about 30 per cent of the observed biomass. We thus get the following estimates:

South Mauritanian potential: 15 000 tons
Senegal-Gambia potential: 51 000 tons

These values are of the same order as the preceding estimates.

The results of the GTS surveys are given overall by geographical sectors the limits of which do not correspond to the land frontiers between the countries. For example, the Bissagos sector extends from the Gambia to the northern third of Guinea and the Guinea sector, from this limit to half of Sierra Leone (Fig. 3). At a first estimate, it can be said that the density off Guinea was equal to half of the densities in the two sectors, weighted proportionally to the respective number of transects of each sector carried out off the Guinean coast. Starting from densities obtained in this way and knowing the areas (Table 1), it is possible to calculate the biomasses and from there to estimate the potentials. For this it is presumed that the deep sea bottoms (50 to 120 m) were at the time unexploited ($Y_m/B_o = 0.5 \times MB_o = 0.2\ B_o$); as regards the coastal bottoms it is presumed that the potential could be equal to 30 per cent of the biomass in view of the existing exploitation (artisanal fishery, trawler fishery).

Sections of depth	Densities (t/km^2)	Areas (km^2)	Biomasses (tons)	$\frac{C_{max}}{B}$	Estimated potentials
0 - 50 m	6.1	34 300	210 000	0.3	60 000 t
50 - 120 m	5.0	39 000	194 000	0.2	40 000 t
Total		73 300	400 000		100 000 t

As with most potentials based on biomass estimates, it is likely that the above results should be considered as a theoretical maximum that can only be obtained if all species are fully exploited, which implies optimal distribution of effort in space and time that is far from ever being reached in practice. Some of the bottoms, rocky ones for example, are very difficult to fully exploit. Everywhere the fleets tend to concentrate their activities on the more expensive and the more abundant species. Estimates obtained through global production models applied to a multispecies fishery take into account the actual conditions of exploitation and correspond therefore to the maximum that can be realized in these conditions. To the extent that fishing effort can be better divided between species (that is to say, in practice, between depths and the seasons), the potentials as they have been estimated by global models should, therefore, be capable of improvement.

All these estimates suffer from the simplified hypotheses that had to be made, the least satisfactory being *a priori* the extrapolation of Guinean potential to Senegal-Gambian and South-Mauritanian sectors on the basis of the ratio of relative densities corresponding to a particular season (cold) and to demersal and pelagic species as a group. We can, nevertheless, suspect that if the division of potentials by national sector risks being clearly biased, the overall estimate for the entire Cape Verde (littoral) division would be more correct. The biomass values such as they have been measured during the GTS campaign lead to an overall potential of 220 000 tons. Bearing in mind the remarks made earlier on the significance of estimates based on a global production model and those deduced from biomass surveys, the agreement between these various evaluations can be considered as quite good (Table 4). (All these figures are without the *Brachydeuterus.*)

A final estimate of catch potential in the Cape Verde (littoral) division can be attemptec through an extrapolation of the assessment available for the Ivory Coast sector (Fonteneau, 1970 and 1971). The extrapolation factor taken is equal to the product of the ratio of surfaces of the continental shelf in the two sectors and that of the average density of the populations such as they have been calculated by Caverivière (1978) starting from average yearly cpue of the Ivory Coast trawlers operating in these two zones. This assessment refers almost entirely to the coastal stretch (0-50 m) (the Ivory Coast stock, whose evaluation is used as a reference, nevertheless, includes small proportions of species captured beyond 50 m) and, therefore, excludes the greater part of the deep water populations, the sparids in particular. In these calculations, the ratio of densities is considered much more exact than previously, since it is based on detailed statistics obtained from operations throughout the year by the same fleet. On the other hand, this extrapolation implicitly admits that the proportion of bottoms that can be trawled is the same in the two sectors and the same is assumed regarding the rates of exploitation and the fishing programmes (on the species) and policy for discards. It is not likely that these conditions are fulfilled. At the same time, the potential of the Sherbro division (Sierra Leone and Liberia) can be assessed. The calculations and the results are summarized in Table 5.

None of these assessments include the bigeye grunter *(Brachydeuterus)* and the other small species, more often than not pelagic, such as the razor fish *(Ilisha africana)* whose biomass is important but which are nearly always discarded by the trawlers. It is possible to put forward an order of magnitude of the extra catch which would allow for the simultaneous commercialization of these species.

Table 4 - Different maximum catch potentials (tons) related to the entire demersal stock and to some particular species in the CECAF Cape Verde and Sherbro Divisions

Sector	Total demersal stock					Particular species		
	Starting from biomass estimates		Extrapolation Ivory Coast potential	Global production models		*Brachy-deuterus*	Cynoglossids	Sparids
	GTS	Echo-integration		Polish data	Japanese data			
South Mauritania (South 19°N)	78500[1]							
Senegal-Gambia	66000[1]					50000[4]	3000	
Guinea-Bissau	40000[1]							
Guinea	100000[1]							
Total Cape Verde (litt.) Division	210-220000[1]	≃ 200000[2]	180000[1][3]	135000[1]	150000	25-40000[5]		70000
Sierra Leone	16000[1]							
Liberia	9000[1]							
Total Sherbro Division	25000[1]		45000[1][3]					

[1] Excluding *Brachydeuterus*

[2] Sector less than the entire Cape Verde (littoral) division

[3] Mainly coastal communities

[4] Potential calculated on the basis of a biomass estimate by echo integration

[5] And other small pelagics, deduced from GTS biomass measurements

Table 5 - Assessment of catch potentials, for demersal species mainly in the 0 - 50 m strip of the Cape Verde (littoral) and Sherbro divisions, obtained by extrapolation of Ivory Coast potential proportional to shelf surfaces and to the relative densities of populations deduced from the comparisons of yields of Ivory Coast trawlers

Sectors	Relative densities[2] (yearly average)	Area (km^2) (10-50 m)	Relative area	Index of potential	Estimated potential (tons)
Ivory Coast shelf[1] (mainly 0-50 m)	1	4 700	1	1	7 000[3]
Sherbro Division (Sierra Leone, Liberia)	1.4	21 500	4.6	6.4	45 000
Cape Verde (littoral) Division (South Mauritania, Senegal-Gambia, Guinea Bissau, Guinea)	1.9[4]	63 900	13.6	25.8	180 000

[1] Reference sector

[2] Calculated by the Robson method from cpue of the Ivory Coast fleet (Caverivière, 1978)

[3] Reference potential (Fonteneau, 1970 and 1971)

[4] The Ivory Coast trawlers mainly operate South of Cape Verde; the figure of 1.9 relative density corresponds to the fishery in this part of the division; it cannot correctly reflect the density of the whole of the division to the extent that mixing inside stocks would be insufficient

Bearing in mind that the resulting estimate of 180 000 tons practically excludes the potential of bottoms beyond 50 m, the result agrees well with other estimates (Table 4) based on totally different data.

The results of the GTS campaign distinguish the "reduced" biomasses (i.e., without *Brachydeuterus* and the catches of small pelagics) from total biomasses (corresponding to all the species captured during the surveys). The ratio of total biomass/reduced biomass is equal to:

$\frac{406}{359}$ = 1.13 for the Bissagos sector (Casamance, Guinea Bissau and North Guinea) and to

$\frac{228}{192}$ = 1.19 for the Guinea sector (southern Guinea, northern Sierra Leone)

(Tables 993 and 994, *In* Williams, 1968). The potentials given in Table 4 should, therefore, be increased in the same proportion, that is 25 000 to 40 000 tons in absolute value, if these species were utilized.

A study by Domain (1974) assesses the potential production of the bigeye grunter at 10 000-12 000 tons for the entire Senegalese continental shelf where he identifies two main areas of concentration, one off Saint-Louis and the other offshore from Casamance. Bearing in mind the method used (area swept), this potential could be underestimated; all the more so as avoidance and escape are high for these species and the gear used.

Using echo integration, Marchal and Boely (1976) have assessed the biomass of *Brachydeuterus* found offshore Casamance at 100 000 tons and at 115 000 tons those situated off the North coast of Senegal. This stock is little fished: the sardine boats avoid it and captures by shrimpers, who discard it, seem comparatively small in comparison to estimates of the biomass. Taking the natural mortality coefficient of 0.5, the potential could be in the order of a quarter of this biomass, that is to say about 50 000 tons, (if it can really be considered as a virgin stock). This figure only refers to the Senegalese shelf. The potential for the overall Cape Verde (littoral) division should therefore be quite higher.

Other partial assessments, relative to stocks or particular portions of the continental shelf, have been publishd. For the tonguefishes on the continental shelf of Senegal, potential maximum production has been estimated at around 3 000 tons (CRODT, not published). Catches reached 3 200 tons in 1974. Unless new fishing grounds are discovered and the rate of mixing is low, this stock must be considered as fully exploited. The cpue for Japanese trawlers of the 5.53 GRT type allows the stock potential for sparids in the Cape Verde (littoral) division to be assessed at 71 500 tons (Attachment 3). This figure was exceeded in 1973 (73 600 tons). Within the family of the sparids, a sharp drop in yields of sea bream *(Pagellus coupei)* has been reported. This has gone from 600 kg/day of fishing (standard 250 hp trawler) in 1973 to 300 kg/sea-day three years later (FAO, 1979a). We must therefore consider that, taken overall or by main species, the sparid stock is currently fully exploited in the Cape Verde (littoral) division.

3.3 The Gulf of Guinea (9°N-6°S)

3.3.1 Data and methods

The assessment of demersal stocks for the Sherbro and Gulf of Guinea (West, Centre and South) divisions has been approached as a whole. In fact, with the exception of the fishery on the Ivory Coast continental shelf and, to a lesser degree, on that of Nigeria for which statistics are available to allow for an assessment of maximum potentials according to the classic models, for all the rest of the region only the results of the GTS campaign can be used to assess the productivity of various sectors of the Gulf of Guinea. This collection of data has been treated simultaneously by the same method.

Since 1958, statistics on the catches and yields of Ivory Coast trawlers have been regularly collected and improved. From 1968 on, these data have been collected separately by sectors of the continental shelf and by sections of depth that are less and more than 50 m, thus giving an independent assessment of the potential of coastal and deep water communities. With these statistics, completed with the results of a recent survey of the demersal biomass of the Ivory Coast shelf, it is possible to study the impact of the proliferation of the trigger fish on the structure and the potential of the demersal fish communities.

The composition, size and activities of the fishing fleets, trawlers and the artisanal fishery, operating South of Liberia have recently been described in great detail (FAO, 1979b). This information will not be repeated here.

3.3.2 Proliferation of the trigger fish

The trigger fish *(Balistes capriscus)* forms part of the sparid coastal community (Longhurst, 1969). Up until 1970, it was not reported anywhere in appreciable densities (never more than some individuals per hour of trawling), whether in the surveys covering all of the Gulf of Guinea (GTS; Williams, 1968) or during fishings repeated systematically throughout the year at various depths of transects perpendicular to the continental shelf (Congo: Durand, 1967; Ivory Coast: Troadec *et al.*, 1969; Bouillon *et al.*, 1969).

Champagnat (personal communication) has noted that the GTS data reveal three spots (Guinea/Liberia, Ghana and southern Gabon) where densities, although weak, were superior to those in the rest of the Gulf of Guinea and that these correspond to three large sectors with a wide extension of hard bottom. This would seem to confirm the original observation of Longhurst on the trigger fish forming part of the coastal sparid community on hard bottoms. However, proliferation of the trigger fish, reported since 1970, apparently only affects the first two sectors; no similar phenomenon has yet been reported offshore from Gabon. It has also been noted that the phenomenon extends well beyond the limits of the hard bottom sectors. Thus, the Ghanaean concentration now covers part of the Ivory Coast continental shelf and extends to the East up to the level of the Dodo River in Nigeria (FAO, 1979b).

The first signs of growth in the trigger fish biomass were seen in Ghana in 1970 (Ansa-Emmim, 1979). This increase only appeared in landing statistics two years later, the species not being familiar to the consumers was not initially commercialized. In Ghana, catches which already represented 25 per cent of the biomass catch of the coastal trawlers in 1972, grew to 43 and 53 per cent in 1973 and 1974 respectively. This percentage climbed to 89 per cent in 1975 and 1976 for the smaller boats of this category (8 to 10 m) (Ansa-Emmim, *op.cit.*). In 1976, the research ship FIOLENT caught 25 tons of trigger fish in an hour and estimated the biomass present on the Ghanaean shelf at 68 300 tons (Robertson, 1977). On the Ivory Coast shelf, this biomass would seem to have been 8 200 tons during a recent trawling campaign by the ORC of Abidjan (Champagnat, personal communication). The bigger abundance of trigger fish on the Ghanaean shelf seems related to the wider extension of hard bottom in this sector. Furthermore, the two biomass estimates correspond to different years and different seasons. Nevertheless, the differences between the two figures could well be excessive.

Offshore from Guinea, a trawling survey carried out in August-September 1976 by the E. HAECKEL (GDR) showed that this species then constituted an essential element of the demersal biomass on bottoms between 20 and 40 m on the one hand, and between 9°30' and 10°30'N on the other hand (Zupanovic and Cissé, 1977). During an acoustic survey carried out by the CAPRICORNE in November 1978, almost all of the biomass detected between two waters over the deep half of the shelf consisted of trigger fish and this was true for all the area surveyed, that is to say, between the island of Sherbro and 11°N lat. (Marchal, Burczynski and Gerlotto, 1979). This biomass has been assessed at 400 000 tons. A second campaign in March 1979 in the same area but extended from the Liberian frontier to 11°N gave results that were very similar both in biomass and in distribution (Marchal *et al.*, in preparation). The limits of the extension of this concentration have not been fixed either to the North or to the South but it is possible that it extends southward off Liberia where hard bottoms are particularly developed1/.

1/ According to a recent report from CRODT, the expansion of the trigger fish now reaches Saint Louis in Senegal where important yields have been obtained by the trawlers and beach seiners in 1979, during the warm season

Simultaneous with the proliferation of the trigger fish, profound modifications have appeared in the systematic composition of the communities and depth distribution of the biomass. These have mainly been studied offshore from Ivory Coast and Ghana. Off Ivory Coast, a classic pattern (on soft bottoms) with two maximums - one toward 25 m corresponding to coastal communities and the other, lower, toward 80 to 100 m corresponding to the deep water community - has replaced a pattern with a single maximum, located toward 40 m, related to the exceptional growth of the trigger fish biomass (FAO, 1979b). Various relationships have been drawn up between this proliferation of the trigger fish and other disturbances in the ecosystem or events that took place around the same time:

(a) collapse of the round sardinella stock (FRU/ORSTOM, 1976). In fact, the coincidence is not very close although such a difference does not prove that the two phenomena are independent. It should be noted that the collapse of the round sardinella stock happened two years after the growth of the trigger fish stock had begun to manifest itself and that this latter phenomenon has a geographical extension that is much greater than the area occupied by the sardinella stock (Troadec *et al.*, 1979);

(b) development of the shrimp fishery, initiated several years previously and centred on the intermediate depths where the trigger fish is located (Garcia, personal communication). In this connexion it should be noted that there has been no proliferation reported in Gabon where no specialized fishery of the shrimp has developed but that, on the other hand, no proliferation of the trigger fish has been reported offshore from the North of Senegal where shrimp fishery has been going on for a long time[1/]. It is worth noting that in northern Senegal and Gabon, we are close to the northern and southern limits of the area of abundance of the species;

(c) marked decline in coastal sparid catches in Ghana where landings have dropped from 10 000 tons in 1970 to 2 000 tons in 1974 (FAO, 1976a): this drop could, at least partially, be due to part of the fishery effort previously centred on sparids being shifted to the trigger fish. No information is available to help clarify this hypothesis.

In fact, the causes and the dynamics of the proliferation of the trigger fish are unknown. Nevertheless, it is true to say that this has been one of the most profound upsets that have been observed up to now in the marine environment. It has also been noted that the eclectic feeding habits of the trigger fish and its great resistance to the consequences of being caught[2/] should give it an advantage in interspecies competition. Even if this superiority is real, what caused the proliferation to start still has to be discovered.

3.3.3 Assessment of Ivory Coast demersal stock

More detailed data - divided into the fisheries of coastal species and deep water species on the shelf - and more precise, normalized measurements of fishing effort (Caverivière, 1978) have allowed for a revision of the first assessments of Fonteneau (1970 and 1971).

The main results of the new assessments (FAO, 1979b) can be summarized as follows (Table 6):

[1/] According to a recent report from CRODT, the expansion of the trigger fish now reaches Saint Louis in Senegal where important yields have been obtained by the trawlers and beach seiners in 1979, during the warm season

[2/] An experiment carried out on the R/V CAPRICORNE has shown that after being 20 minutes out of water following capture in the trawl, the species survived at least 15 days in the fish well

(a) prior to the proliferation of the trigger fish, the potential was between 7 000 and 9 600 tons (depending on the data and the mathematical models used). This result is less thar the absolute potential, as the deep section (50 to 200 m) is only exploited for a few months in the year during the upwelling period and at reserved depths,i.e.,when and where the availability of the sea bream *(Pagellus coupei)* and the dentex (*Dentex* spp.) is sufficient to ensur‹ profitability in the fishing of these bottoms;

(b) with the help of global models applied to Ivory Coast fishery statistics, the potential of the coastal strip has been estimated at 4 400 tons (without the trigger fish) and 5 300 tons (with the trigger fish), and that of the deeper section as being 1 800 and 2 900 tons, also depending on whether or not the trigger fish is excluded;

(c) recent survey has assessed the biomass present on the deeper part of the shelf at 11 500 tons and for the coastal section as 9 300 tons. Gulland (1971) indicates that at the level of maximum production of the Schaefer model: $C_{max} \simeq MB_{max}$. The assessment mentioned above indicates that the stock is actually close - but within - this state for which we also take M as being close to F. If we take $M \simeq 0.4$ we get for example:

$$C_{max} = 0.4\ B_{max} = 0.4 \times 9\ 300 \text{ tons} = 3\ 720 \text{ tons}$$

for the coastal sector.

This estimate supposes that the effort is divided in a uniform way over the different species composing the community. Comparison of this figure to the estimate obtained with a Schaefer model (4 400 tons) (that is to say,bearing in mind current exploitation conditions of this multispecies stock, particularly the distribution of fishing effort on the various species), shows that an increase in the productivity of the coastal stock by changing this division of effort is very unlikely.

On the other hand, a comparison of the ratios $\frac{\text{Maximum potential (global model)}}{\text{current biomass}}$ $(\frac{4\ 400}{9\ 300} = 0.5$ for the coastal stock and $\frac{1\ 800}{11\ 500} = 0.2$ for the deep water stock) shows that it should be biologically possible to increase the level of exploitation of the deep water stock. This conclusion confirms the episodic and localized exploitation of this stock. In order for it to be fully utilized, it would be necessary on the one hand to improve the division of effort on the whole of the stock making up the ecosystem and, on the other hand, to commercialize almost the entire totality of the catch. That, unfortunately, does not seem to be currently possible for economic reasons;

(d) for the shelf as a whole, the proliferation of the trigger fish corresponds to a drop of 30 to 40 per cent of the actual potential realizable with the species that are traditionally commercialized (5 800 tons as against 9 600 tons according to a PRODFIT model; 4 400 tons + 1 800 tons as against 8 600 tons according to an exponential model). The potential of the trigger fish stock (that can be approximately estimated to be at least 2 000 tons on the basis of its biomass, and assessed by survey at 8 200 tons) is the equivalent, approximately, to this loss of effective potential. The productivity of the ecosystem would thus seem to have remained much more stable than its composition;

(e) under the current conditions of exploitation, the productivity (maximum potential per unit of surface) of the demersal communities is the following:

Depth sector	Without commercialization of the trigger fish	With commercialization of the trigger fish
0 - 50 m	$\frac{4\,400\ \text{t}}{4\,700\ \text{km}^2} = 1.0\ \text{t/km}^2$ approx.	$1.15\ \text{t/km}^2$
50 - 200 m	$\frac{1\,800\ \text{t}}{7\,600\ \text{km}^2} = 0.25\ \text{t/km}^2$ approx.	$0.4\ \text{t/km}^2$

In the case where the biological potential could be fully utilized, productivity could reach $0.9\ \text{t/km}^2$ for all of the shelf and, perhaps, $0.75\ \text{t/km}^2$ for the deeper parts;

(f) the maximum sustainable yield corresponding to current conditions of exploitation has not been reached either for the coastal stock (catch 1977: 4 300 tons) or for the deep water stock (catch 1977: 1 740 tons), mainly for economic reasons in both cases. In fact, the fishing effort has shown a tendency to diminish from 1969, especially from 1973 to 1976. The fact that this occurred simultaneously for both stocks (which would suggest that it is a consequence of an identical growth in costs) and the identical extent of the improvement in yields which has resulted, leads one to think that the cause could reside in the increase of the cost of energy as well as in the freezing of prices locally, particularly through the importation of fish.

Table 6 – Results of various assessments of the demersal fish potential of the Ivory Coast continental shelf

Section of depth	Prior to proliferation of trigger fish (1970) potential (reference; model)	After proliferation of trigger fish	
		Potential trigger fish excluded (reference; model)	+ trigger fish potential (biomass 1978 = 8000 t)
0-120 m	8-9000 t (Fonteneau, 1970; Schaefer) 7000 t (Fonteneau, 1971; Schaefer) 8600 t (FAO, 1979b; exponential) 9600 t (FAO, 1979b; PRODFIT)	5800 t (FAO, 1979b; PRODFIT)	+ 2000 t = 7800 t
0-50 m		4400 t (FAO, 1979b; exponential)	+ 900 t = 5300 t
50-120 m		1800 t (FAO, 1979b; exponential) under current economic conditions	+ 1100 t = 2900 t
		4500 t (Potential biologically possible)	+ 1100 t = 5600 t

3.3.4 The Ghanaean shelf

In Ghana, Rijavec (*In* FAO, 1972a), using results obtained from systematic trawling surveys, has estimated the demersal biomass present at between 20 and 70 m (i.e., on an area of around 15 000 km^2), as being 34 000 tons. The corresponding density is around 2.3 t/km^2. The reported catches were around 6 000 tons, including 1 000 tons caught by Ivory Coast trawlers but not including the discards, (which were unknown but very likely quite large). A comparison of these figures on the basis of the reasoning presented in Section 3.3.3 leads one to think that the stock was not yet fully exploited and that its potential could be in the order of a third of the biomass estimated by Rijavec, that is to say a little above 10 000 tons (or 0.7 t/km^2). This first estimate is less than that obtained for Ivory Coast by the application of a global model to trawler statistics in the coastal strip. By comparing the yields obtained by Ivory Coast trawlers in the two sectors, Caverivière (1978) has shown that abundance in the Ghanaean sector has always been, over the past fifteen years, from 15 to 35 per cent superior to that of the Ivory Coast sector. This difference could be due to the fact that the Ivory Coast sector has always been more intensively fished. If the degree of exploitation is comparable, at least in certain periods, this would signify that the Ghanaean stock is comparatively more productive. In this case, bearing in mind the relative confidence that one can give to the two estimates (that of the Ivory Coast stock with the help of a production model and that of the Ghanaean stock based on biomass estimates), we should have to admit that the potential of the Ghanaean stock is underestimated (for example by the bias introduced during trawling by fish avoiding the net). The available information is not enough to clarify this point.

We also have to note that in the sectors where there is considerable extension of the hard bottom into the deep water part of the shelf, the contrast between the rich coastal strip and the poor deep water stretch is reduced. This observation favours the hypothesis of a higher overall productivity for the Ghanaean sector as opposed to the Ivory Coast sector.

Extrapolated to the whole of the Ghana-Togo-Benin sector, the assessment based on the survey of the Ghanaean shelf gives a total demersal potential of 17 000 tons. This extrapolation supposes that the overall productivity has not been greatly altered by the proliferation of the trigger fish - as had been the case in Ivory Coast - and that the populations of Togo and Benin are not too different from those of Ghana - something that the surveys indicated.

3.3.5 The Nigerian shelf

Longhurst (1964) estimated that at the beginning of the sixties, the sector between Cotonou (Benin) and Lekke (Nigeria) was being fully exploited by the fleet of trawlers based in Lagos. Bayagbona (1965, 1968) concluded that the stock of West African croakers (*Pseudotolithus* spp.) fished by the same fleet showed signs of overexploitation and suggested the adoption of a mesh size of 75 mm. In the southern part of the Gulf of Guinea (Congo, Zaire), Le Guen (1971) and Troadec (1968, 1971) showed that at the same period the stock of *Pseudotolithus elongatus* and *P. senegalensis* fished by the trawlers based at Pointe-Noire (Congo) were too intensely fished and with a too small a mesh (40 mm stretched).

Longhurst (1965) advanced as an order of magnitude the following figures for the demersal potential of the Nigerian continental shelf:

trawler fishery - coastal strip (0 - 50 m)	11 000 tons (0.4 t/km^2)
- deep water strip (50 - 200 m)	3 500 tons (0.25 t/km^2)
artisanal fishery (concentrated in the coastal strip)	25 000 tons
Total	40 000 tons approx.

If we calculate the artisanal production with the coastal potential; these productivity figures are quite comparable to those obtained for the Ivory Coast shelf starting from more accurate data. The former should be considered as a maximum to the extent that, unlike the Ivory Coast coastal strip, the Nigerian shelf does not have a seasonal upwelling.

The total demersal catches in Nigeria and the available cpue for the Nigerian trawler fleet can be used to evaluate the stock that these boats fish, at least if we ignore the statistics after 1969, (the catches from this date onward seem to be clearly overestimated). These data (CECAF archives) have been processed by a Schaefer model (Attachment 4), and give a maximum potential of 25 000 tons. This result is below that obtained by Longhurst, but it is likely that several causes of underestimating have played a role in the estimate deduced from a global production model: imperfect identification of total demersal catches in the national statistics (the problem of breaking down the item "various"); an undeclared activity of foreign ships in the Nigerian sector; reduced exploitation of the deep water community (or none at all); no account taken in the production model of discards, and finally, mortality among the juveniles of the various demersal species as a result of the development of shrimp fishery. It is not possible to quantify the effect of these factors that can lead to underestimation, but it can be imagined that it is quite appreciable.

3.3.6 Assessment of demersal potential for all of the Gulf of Guinea on the basis of estimates of biomass supplied by the GTS campaigns

Estimates of biomass supplied by the GTS campaign (Williams, 1968) can be used to check the evaluations of demersal potential on the Ghanaean shelf and the Nigerian shelf and to evaluate those of other sectors for which no estimate has been made. The average biomasses (taken from the overall results of the two campaigns that were carried out at six-monthly intervals) are given separately by sector (see their limits in Fig. 3) and by sections of depth (15-50 m and 50-200 m) in Tables 993 and 994 of the report (Williams, *op.cit.*). These tables distinguish between the total biomass corresponding to the total catch of "reduced" biomass, i.e. without the bigeye grunter *(Brachydeuterus auritus)*, the small pelagics and the other species fished occasionally but always in small quantities. These biomasses are reduced directly from catches made in the area swept, i.e., without any correction aimed at taking into account escapes and the gathering together of fish by the arms of the trawl inside the area being swept.

On the basis of what is known about the development of the trawler fishery along the length of the Gulf of Guinea, an approximate assessment has been made of the degree of exploitation (from 0 = zero exploitation to 4 = full exploitation) taking place at the moment of the GTS campaign on the demersal stock in the different sectors and depth ranges. Watts (1962) considers that in 1960-61 the stock on the bottom where the trawlers from Sierra Leone operate were overexploited. This observation probably does not apply to all the species and at all depths of the Sierra Leone shelf. The deeper strata were probably little exploited or not exploited at all, and the same was probably true for the coastal strip off Liberia because (in the latter case) of poor yields and the amount of hard bottoms. The coastal Ivory Coast stock was fully exploited (Fonteneau, 1970 and 1971) as was, probably, most of the Ghanaean shelf and the western part of the Nigerian coastal stock (Longhurst, 1964 and 1965). For the area that spreads South, from Cameroon to the mouth of the Congo, the FAO 1979b report has been used to get information on the degree of exploitation for the various sectors. The probable ratios for maximum potential/biomass have been fixed empirically on the basis of the approximate equations $C_{max} = 0.5 MB_0$ (in the case of an unexploited stock) $\approx 0.5 ZB$ (in the case of stock already exploited) (Allen, 1971; Gulland, 1971; Troadec, 1977), while taking an average M of 0.4. Thus, the ratio for the non-exploited sectors was fixed at 0.2 and at 0.4 for those which were fully exploited. The various steps in this procedure, starting from the original GTS values, are given in Table 7.

This procedure ignores the effects of mixing, within stocks, between adjacent sectors. The consequences are not, perhaps, very serious to the extent that the movement of demersal stock seems to be slight inside the Gulf of Guinea.

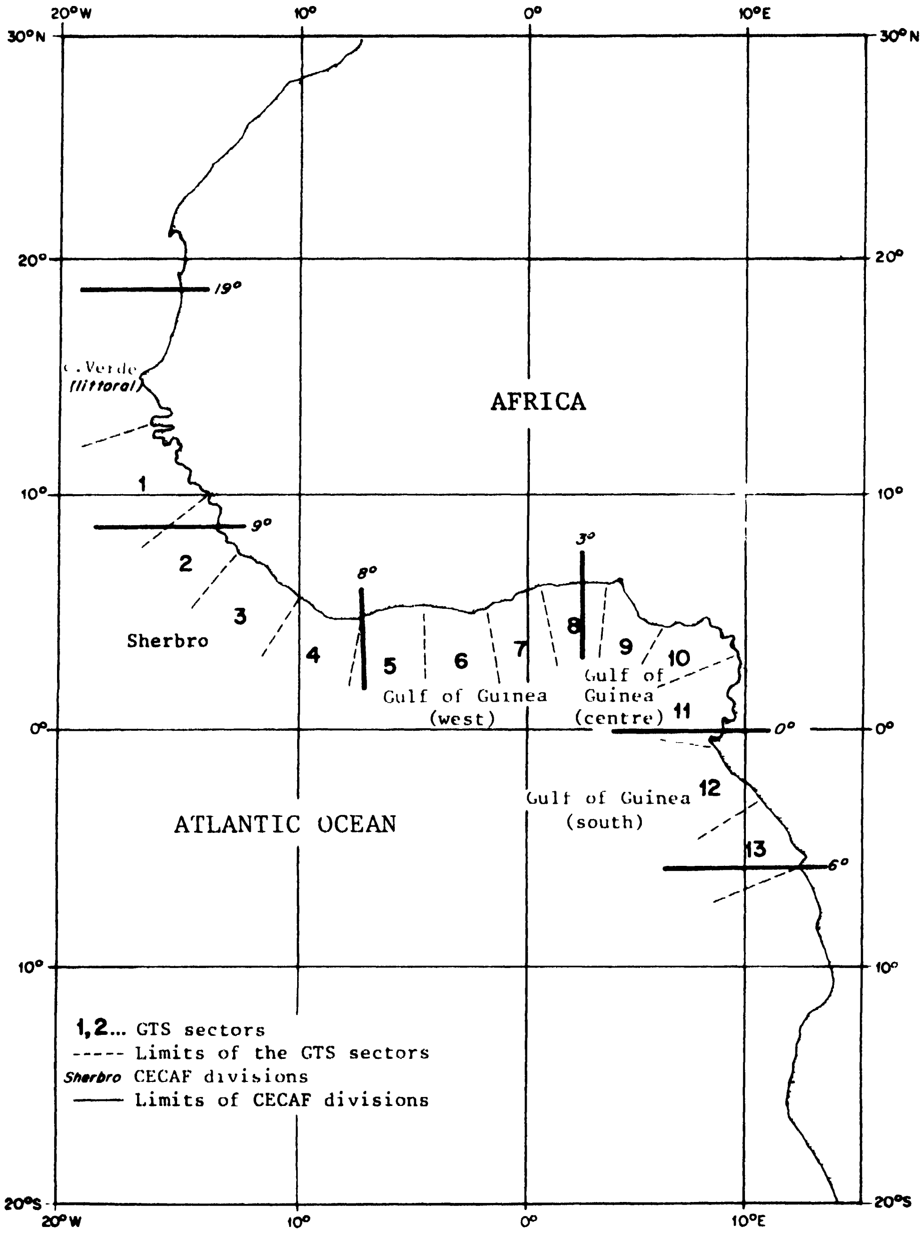


Figure 3 - Geographic limits of the statistical divisions of CECAF and the sectors used for the processing of results of the GTS survey.

Table 7 gives, for each GTS sector and for four groups of sectors corresponding more or less to the four CECAF divisions (Sherbro, Gulf of Guinea West, Centre and South), the following results:

- the potential of the coastal strip, with and without the bigeye grunter and the other small accessory species;

- the potential of the deep zone (also with and without these species). This potential corresponds to a biological potential which, in the less rich sectors, cannot actually be reached, as the corresponding yields are not sufficiently profitable at the economic level (FAO, 1979b).

From all these raw data, the following conclusions emerge:

(a) the potentials and productivities (t/km^2) fall very drastically starting already from Sierra Leone to show a net rise only in the most southern GTS sector (Congo-Cabinda-Zaire). If the potential of the Cape Verde division was in the order of 200 000 tons, that of the Sherbro division was below 75 000 tons; those of the divisions of Gulf of Guinea (West and Centre) of around 30 000 each, and that of the Gulf of Guinea (South) division a little less than 50 000 tons (the limits of the GTS sectors do not correspond exactly to the limits of the CECAF divisions, Fig. 3);

(b) the bigeye grunter *(Brachydeuterus auritus)* and the other small associated species represent about a third of the potential of the coastal strip, i.e., about 50 000 tons for the Gulf of Guinea overall (to which must be added at least the equivalent potential present in the Cape Verde (littoral) division);

(c) the poverty of the Sherbro division (South of Guinea) and of the Gulf of Guinea (Centre) division is confirmed. The same is true for the deep water stock especially in the poorer zones, that is to say from the island of Sherbro to Cape Palmas, on the one hand, and from Nigeria to Cape Lopez (Gabon) on the other. To the poorness of the overall productivity of the Gulf of Guinea we must obviously add the narrowness of the continental shelf to the South of the Bissagos archipelago;

(d) in the sectors where there are a lot of bottoms that cannot be fished by trawling (Liberia, South Gabon), potentials were calculated by the use of fishing gear other than the trawl (longlines, lines, trammel nets, fish pots, etc.).

The weakest points of this assessment lie in the estimate (partially subjective) of the rates of exploitation applied to the stocks in the different sectors, and in the estimate of the absolute biomass on the basis of trawl catches (unknown effect of the avoidance and of the herding together of the fish is totally ignored).

Although the limits of the sectors do not correspond exactly to those of the stocks evaluated previously by the classic methods, it is possible, nevertheless, to make a rough comparison of the results obtained for the same sectors. First of all the similarity of productivities (t/km^2) for the Gulf of Guinea (West) is very noticeable.

	GTS Data (Ivory Coast-Ghana)	Global Model (Ivory Coast)	Survey (FAO, 1972a) (Ghana)
Coastal strip (with *Brachydeuterus*)	1.3 t/km^2	1.15 t/km^2	0.7 t/km^2

Again, even though the limits of the two series of assessment do not correspond exactly, it is possible, starting from GTS data, to estimate the potential of the Ivory Coast shelf at about 7 000 tons for the coastal stock and between 3 000 and 4 000 tons for the deep sea stock. The results are exactly comparable to those obtained with a global model and the data on the performances of the Ivory Coast fisheries.

Table 7 — Gulf of Guinea (10°W-6°S): Assessment of the potential of demersal fish based on estimates of biomass supplied by the GTS campaigns (Tables 993 and 994, *In* Williams, 1968)

Coastal countries	GTS sector (Fig. 3)	Depth section (m)	Biomass (000 t)		Degree of exploitation	Potential Biomass	Potential (000 t)		Productivity (t/km^2)	
			Total	Reduced1/			Total	Reduced1/	Total	Reduced1/
Guinea - North Sierra Leone	2	15-50	188	155	3-4	0.35-0.4	66-75	54-62		
		50-200	40	37	1	0.25	10.0	9.3		
South Sierra Leone - North Liberia	3	15-50	18	8	1	0.25	4.5	2.0		
		50-200	27	23	0	0.20	5.4	4.6		
South Liberia	4	15-50	7	3	1	0.25	1.8	0.8		
		50-200	18	10	0	0.20	3.6	2.0		
Total3/	2+3+4	15-50					70-80	57-65	1.75-2.0	1.4-1.6
		50-200					19 2/	16 2/	0.8 2/	0.7 2/
West Ivory Coast	5	15-50	11	7	4	0.40	4.4	2.8		
		50-200	11	10	1	0.25	2.8	2.5		
East Ivory Coast - West Ghana	6	15-50	14	8	4	0.40	5.6	3.2		
		50-200	30	20	2	0.30	9.0	6.0		
Centre Ghana	7	15-50	27	18	3	0.35	9.5	6.3		
		50-200	38	27	2	0.30	11.4	8.1		
East Ghana - Togo - Benin - West Nigeria	8	15-50	13	9	3	0.35	4.6	3.2		
		50-200	12	10	1	0.25	3.0	2.5		
Total3/	5+6+7+8	15-50					24	16	1.3	0.8
		50-200					26 2/	19 2/	1.1 2/	0.8 2/
Centre Nigeria	9	15-50	35	21	4	0.40	14.0	8.4		
		50-200	12	10	0	0.20	2.4	2.0		
East Nigeria - North Cameroon	10	15-50	21	14	3	0.35	7.4	4.9		
		50-200	20	18	0	0.20	4.0	3.6		
South Cameroon - Equatorial Guinea - North Gabon	11	15-50	13	11	1-2	0.27	3.5	3.0		
		50-200	26	22	0	0.20	5.2	4.4		
Total3/	9+10+11	15-50					25	16	1.1	0.7
		50-200					12 2/	10 2/	0.5 2/	0.4 2/
South Gabon	12	15-50	25	20	2	0.30	7.5	6.0		
		50-200	49	37	0	0.20	9.8	7.4		
Congo - Cabinda - Zaire	13	15-50	79	41	4	0.40	31.6	16.4		
		50-200	79	57	1	0.25	19.8	14.3		
Total3/	12+13	15-50					39	22	2.3	1.3
		50-200					30 2/	22 2/	1.2 2/	0.9 2/
GRAND TOTAL	2 - 13	15-50					160 -169	111 -119	1.6-1.7	1.1-1.2
		50-200					86 2/	67 2/	0.9 2/	0.7 2/

1/ Reduced biomass = total biomass less turtles, squid, shrimp, sardinellas, *Caranx* spp., *Decapterus* sp., *Trachurus* spp. and *Brachydeuterus auritus*

2/ Biological potential, probably partially realizable now for economic reasons in the less rich zones

For the stock exploited by the Pointe-Noire (Congo) trawlers, Fontana (personal communication) estimates that the potential for the Congolese shelf alone could be around 8 000 tons (excluding *Brachydeuterus*) the catches having levelled off at this level when the effort increased. Now, while proportionally interpolating the GTS results to the area of the shelf, we get, for the Congolese shelf alone, an average maximum production of 6 000 or 12 000 tons *(Brachydeuterus* excluded*)*, depending on whether the interpolation is based on the potential of the GTS sectors 12 and 13 or on that of the GTS sector 13 only (Table 7).

Finally, with regard to the coastal stock of the Sherbro division, we obtained, by extrapolation of Ivory Coast potential, an estimate of 45 000 tons (Table 5). Using the GTS data we arrive at a figure of around 60 000 tons for the GTS sectors 2, 3 and 4 (without the *Brachydeuterus,* as this species is not generally kept by the trawlers fishing in this zone). While this group of sectors has the same southern limit, it extends northward, over much richer bottoms, decidedly beyond the limit of the Sherbro division (Fig. 3). The non-coincidence of the northern frontiers could very well explain the considerable difference between the estimates.

We can thus conclude that the order of magnitude of the potential assessments deduced from the data of the GTS campaign and, above all, the relative richness of the various sectors of the Gulf of Guinea, have been correctly assessed.

It has also been noted that the two estimates obtained for Cameroon do not agree with the larger catches reported by that country for a number of years. This could be explained by the fact that a large part of the catches are made in very coastal zones and in the many large river mouths which have not, up to now, been subject to any investigation. These areas are, in effect, special environments where the terrigenous supply, and the extent of the mangroves, constitute factors of enrichment that can compensate for the poor oceanic productivity of this part of the Gulf of Guinea (FAO, 1979b).

4. CONTROL OF MESH SIZE

The sizes of mesh usually used in the Gulf of Guinea are too small, whether it is for trawlers that are usually equipped with a mesh size of 40 mm (stretched) or the beach seines used by the artisanal fishery (FAO, 1979b). Furthermore, existing national legislations are often poorly applied (FAO, 1979d). In 1973, CECAF had recommended the prohibition of mesh openings of less than 70 mm for hake and sparid fisheries and suggested that the cephalopods should not be fished with meshes of less than 60 mm (FAO, 1972; Gulland, 1979). These recommendations were based on assessments concerning the stocks of the northern sector of CECAF (Morocco, Sahara and Cape Verde divisions) and, therefore, do not apply to those which are found South of Cape Verde. Although such legislation only marginally concerns the stocks being considered in this summary, it is to be hoped that these proposals can be reviewed and confirmed in the light of the scientific data collected over the last few years. In particular, the effect on the legislation of accessory shrimp catches realized during the hake fishery on the slope needs to be analysed (FAO, 1979d).

For the tropical stocks of the Gulf of Guinea, the scientific data up until recent years have generally been insufficient to permit the drawing-up of regulations that could be applied to all the species being exploited simultaneously, particularly by trawling. Some authors (Longhurst, 1964 and Bayagbona, 1965 and 1968 in Nigeria; Le Guen, 1971 and Troadec, 1971 in the Congo) had carefully analysed the theoretical effects on the yields of *Pseudotolithus senegalensis* and *P. elongatus* that could be expected as a result of the increase in the size of first capture. These works led Longhurst and Bayagbona to propose a mesh size of 75 mm for the croaker fishery in Nigeria.

Nevertheless, the croakers *(Pseudotolithus senegalensis* and *P. elongatus)* are among the largest size species taken by trawling, and it is clear that the optimum mesh size for these species will not be suitable for the species as a whole that are captured simultaneously, which are, on the average of a smaller size. For example, Fontana (1974) in the Congo concludes that, for the prevailing level of exploitation at that time, a mesh size of 60 to 65 mm would have been adequate for the small species *(Brachydeuterus auritus, Pteroscion peli,* *Pentanemus quinquarius)*, while the larger species *(Pseudotolithus* spp.*)* would have required a mesh size of 70 to 75 mm. This last result is in agreement with the conclusions reached by Longhurst and Bayagbona. In Senegal, the oceanographic research centre at Dakar-Thiaroye has recommended a mesh size of 50 mm for specialized shrimp fisheries (*Penaeus* spp.) and the West African goat fish *(Pseudopeneus prayensis)* and 70 to 75 mm for the fishery of other species. More recently, Lhomme (1977) and Garcia and Lhomme (see the following section of this document) have shown that a widening of the present mesh size (40 to 50 mm) of the shrimp trawlers would be beneficial for the exploitation of species of fish whose juveniles are captured *en masse* in the shrimp fisheries and are then discarded. Such an increase would not change the benefits to the shrimp fishery because the selectivity curves of this species are practically identical for mesh sizes of 50, 60 and 70 mm. Nevertheless, only a thorough study of discard practices and the assessment of the mortality of the fish juveniles and the consequences on their recruitment to the fish trawling fishery, would permit the quantification of the benefits of such a regulation.

Quite recently, in a study of the Congolese trawler fishery, Fontana (1979) has shown, on the basis of analytical models (Ricker type) based on the six main species caught *(Pseudotolithus senegalensis, P. typus, Pteroscion peli, Pentanemus quinquarius, Galeoides decadactylus* and *Brachydeuterus)*, which provide around two thirds of the supply, that by adopting a mesh size of 77 mm, doubling the fishing effort and commercializing the bigeye grunter *(Brachydeuterus)*, the stock would then be fully exploited. Total catches which are actually 6 000 tons should then double. This presupposes a considerable increase in investment, which would probably not be profitable as the average market value of landings would diminish, the increase in catches having to come, above all, from small sized species such as the bigeye grunter Nevertheless, by adopting an intermediary size, for example a mesh size of 60 mm in the fish fishery as for the shrimp, should give a triple advantage:

(a) increase the production of demersal stocks of the Gulf of Guinea, which is an important result if we consider the very poor prospects for expansion and the serious current deficit in local supply;

(b) protect the juveniles of numerous fish species which are now taken as a by-catch in the shrimp fisheries;

(c) and finally, the adoption of a common regulation for two fisheries (shrimp and fish) would be a great help in the effective application of rules and regulations.

These arguments have led the special CECAF working group on the assessment of demersal stock in the Ivory Coast/Zaire sector to recommend the adoption of just such a size (FAO, 1979b).

The same group also suggested that, in countries where the beach seine fishery is important (Benin, Ghana, Togo,for example), sampling programmes be rapidly undertaken in order to quantify the amounts, in weight and number, that are caught, as well as the composition of the catches by species and size of captures. The objectives of this study would be to analyse what effects the taking of large catches of fish juveniles (for which this fishery is responsible), might have on their subsequent exploitation.

5. PROSPECTS FOR EXPANSION AND NEW RESOURCES

Bearing in mind the high degree of exploitation that is already brought to bear on the vast majority of the stocks analysed in this study, it has to be concluded that the present prospects for expansion of the demersal fishery are modest with regard to the Gulf of Guinea as a whole and its neighbouring areas. Apart from some local exceptions, no notable growth in production can be expected for those stocks that are the most fished and the most abundant *(Pseudotolithus* spp.*, Galeoides, Cynoglossus* spp., etc. in the coastal community on soft bottoms; sparids in the Cape Verde and, probably, Sherbro divisions, for example). These species seem, in fact, to be everywhere overexploited, first of all because their commercial value makes them a target species on which the fishing effort concentrates and then because of the small mesh sizes currently used by the trawlers. The latter is all the more damaging to their good exploitation as their average size is, in general, superior to that of the other species caught simultaneously. In the case of all these overexploited species, an appropriate reduction in fishing effort and the adoption of larger mesh sizes should lead to a modest improvement in catches and, probably more important, to a distinct improvement in the profitability of their exploitation.

According to the assessment of Ivory Coast stock (FAO, 1979b), it would, however, seem that, taken overall, the coastal community of the soft bottoms of the Gulf of Guinea are not fully exploited everywhere. Such phenomena as the recent increase in the cost of energy and the competition from low priced fish imports, have very likely brought about a reduction in the rates of exploitation applied to this community in the Gulf of Guinea as a whole. Even so, the results that can be expected from a renewed intensification of the fishery still remain modest.

This does not, however, mean that all increase in production is impossible, even if such an achievement would still be difficult at the economic and administrative levels. There is considerable potential (at least for countries that suffer from a marked deficit in production), in the intensification of the exploitation and in the better utilization of species that are already being caught but which are totally or mostly discarded at the present time. A comparison of the assessments obtained from total biomass measured by surveys, and those drawn from global models applied to past performance of fisheries (and thus indirectly taking into account the selectivity of exploitation and commercialization of the various species that make up multispecies stocks), has shown that the biological potential of these stocks has not been fully utilized.

The first improvement that can be envisaged could be for a better commercialization of the species that are already caught during trawler operations but that are still for the most part discarded. The first of these is the bigeye grunter *(Brachydeuterus auritus)*, whose biomass represents the most abundant element of the demersal biomass of the Gulf of Guinea (Williams, 1968). If we admit that this species constitutes, with the accessory catch of some small pelagics - *Ilisha africana, Chloroscombrus chrysurus,* etc. - the main difference between the total biomass and the reduced biomass as they have been estimated during the GTS campaign (Table 7) (and if we bear in mind the fact that this campaign did not cover the Senegalese-Mauritanian sector), we can see that the potential of this stock could be more than 100 000 tons for the overall sector studied here. The fact that this species is already commercialized in those countries and during those seasons when there is a shortage of fish supplies shows that a better utilization of this fish is indeed possible.

The second species which offers comparable prospects (at least at the present moment though it cannot be excluded that the stock could diminish just as rapidly as it proliferated) is the trigger fish, particularly in the Ghanaean and Guinean sectors where its abundance seems to be maximum. Its current potential is not known, but the various biomass estimates that are available show that it should be more than 100 000 tons. Its utilization depends on promotion with the consumer who is still not fully familiar with this species.

Other stocks could also be better utilized to the extent that it may be possible to use more efficient gear, methods or fishing tactics. Assessment of Ivory Coast stocks has shown that, in the Gulf of Guinea, the deep water stocks (70 to 120 m) largely remain underutilized. (Although the necessary data to support such a supposition are not available, it is not to be excluded that the bottoms from 70 to 120 m are only marginally exploited in the least productive sectors of the Gulf of Guinea.) At a strictly biological viewpoint, these stocks could produce more; first if they were more intensely exploited, and then, especially, if it were possible to shift a large part of the effort toward these species that up to now have been the less sought-after species. It is known, in fact,that the exploitation is concentrated in a very selective way on the *Dentex* spp. and the sea bream *(Pagellus coupei)* when these are more easily available during the upwelling season. It can be supposed that this selectivity of exploitation could increase even more with the increase in energy costs and fishing costs.

The idea has been put forward that the stocks of horse mackerel, mackerel and sardine *(Paracubiceps ledanoisi)* that are practically unutilized in the Gulf of Guinea and are more abundant on the deeper sections of the shelf, could make a considerable contribution in bringing about a better utilization of these deep water stocks, particularly if, following the practice of the fishery in the northern sector of CECAF, a deep water trawl and a mid-water trawl could alternate during the day and the night. Unfortunately it is to be feared that these stocks are not sufficiently abundant in the Gulf of Guinea. But in view of the large deficit in supplies to the countries bordering on the Gulf of Guinea, this point should nevertheless be checked through systematic biomass surveys and simulated fishery campaigns using the most appropriate fishing gear and units.

The hard bottoms, that cannot be trawled, represent another possibility of expansion in the demersal fishery, in those areas where they are extensive and their exploitation is still modest (Gabon and, perhaps, Liberia). Such hard bottoms, for example, cover 60 per cent (23 000 km^2) of the Gabon area of the continental shelf. The potential of the stocks which live there could be more than 10 000 tons (FAO, 1979b). But their valorization depends on the implementation of other methods of fishery: lines, longlines, gillnets, pots, etc. To the extent that these bottoms are not too far from the coast, they could, as the example of the Senegalese and Ghanaean fisheries has shown, offer interesting possibilities for the local artisanal fisheries, which are more diversified, and more flexible with regard to the gear that they can employ.

The progress that could be made in the commercialization of species that up to now have been neglected, or in the improvement of fishing methods so as to intensify the exploitation of stocks that up to now have been disdained, should bring about an improvement in current schemes of distributing fishing effort over all stocks capable of being exploited simultaneously. Such modifications could come about sooner in the less rich sectors where the deficiency in supply should encourage (through an increase in the market price at landings), the exploitation of stocks whose fishery is now only marginally profitable (provided there is no massive recourse to the importation of cheap fish to meet the deficit in local production). However, biologically speaking, these prospects should be better in the richer sectors (Cape Verde and Sherbro divisions), because, on the one hand, stocks there are comparatively more abundant and, on the other hand, because this abundance should, by deflating the local markets, increase the selective character of the exploitation.

A direct intervention aimed at changing current schemes for the division of effort on the various species making up the main communities could, theoretically, permit the ponderal production also to grow. Unfortunately, such management seems very difficult to realize immediately, and it is probable that it is not economically justified. Direct control, that is to say by administrative interventions and not by actions at the level of commercialization and methods of fishery, is,in fact, even more complex to realize and can only be envisaged once we are in the position to control the overall level of exploitation (size of fleets, volume of their activity, etc.) of the fishery as a whole. Now, in spite of the urgency of the question, efficient mechanisms for the control of effort still have to be set up in most countries. At the economic level, the shift of effort toward species that are currently by-catch inevitably brings about a drop in the average price of the fish landed. It is, therefore, possible to ask ourselves if such an intervention would be opportune bearing in mind that much of the fisheries in the region are stabilized at levels that barely achieve profitability.

However, it would be wise to study now the advantage (and the practical measures that could be used to achieve it) of a segregation of activity for the various trawler fleets in order to get a clear regulation of the fishery effort exercised on each of the main single and multispecies stocks (coastal stocks, deep water stocks, shrimp, mullet, etc.) in the same geographic sector.

The development of exploitation of species or bottoms that are still unexploited is more problematical. The overall data acquired from previous intensive commercial exploitations and from systematic surveys (GTS campaign, for example) now seems sufficiently solid for it to be confidently stated that the possibilities of creating new fisheries are slight. This conclusion does not exclude the possibilities of local developments similar, for example, to the recent extension up to the Sherbro division of the cephalopod fishery that was initially limited to the Sahara division.

At the moment, only the continental slope inside the Gulf of Guinea *sensu stricto* remains unexploited. Trawler surveys that have been carried out there (particularly Durand, 1967; Williams, 1968; Troadec *et al*, 1971) have always given discouraging results with regard to the yields supplied by classic species of fish: *Dentex angolensis*, hake *(Merluccius polli)*, etc. To the fall in the biomasses is added a reduction in the proportion of species that can be commercialized as well as the difficulties in trawling on sloping and uneven bottoms. The fact that deep water trawling based on classic species (hake and deep water shrimp, in particular) has for several years been well developed from Senegal on up northward and from Angola down southward and that several fleets (Spanish,for example) operate in the two adjacent sectors also suggest that in the Gulf of Guinea economic yields are insufficient to support these fleets.

Nevertheless, it is not at all certain that some specialized fisheries (gear, species) would not be viable. The concentrations of short-finned squid *(Illex illecebrosus)* as far as one can judge by the trawler fishery (Durand, 1967; Williams, 1968; Troadec *et al.*, 1971), suggest that it could be interesting to test the commercial yields that can be obtained with certain technologies (fishery with ripping hooks, fishery with lights, etc.) and a suitable knowhow.

In Senegal, where the bottoms are richer, good yields of *Brotula barbata* have been obtained on the slope since 1974. The deep water shrimp *(Parapenaeus longirostris)* could help to make the fishery profitable. For this species, which inhabits the deep sections of the shelf and the upper levels of the slope, Crosnier and de Bondy (1967) have mentioned hourly yields of 40 kg off-shore from Mauritania, 61 kg off-shore from Senegal, 13 kg off-shore from Cape Palmas and finally, 16 kg off-shore from the Congo. Cayré (1976) confirms the presence of deep water shrimp in appreciable quantities off-shore from the Congo.

From 500 to 800 metres, the presence of large shrimp *(Aristeus varidens, Plesiopenaeus edwardsianus* especially) is also known (Crosnier and Tanter, 1968). But the fact that, as with the hake fishery, the foreign fleets specialized in their exploitation operate from Morocco to Senegal and from the Congo to Namibia while neglecting the Gulf of Guinea suggest that the populations must be economically insufficient. It still remains to be seen if they would not, however, be sufficient to justify the activity of a small number of trawlers based locally.

We now have good information on the availability of the deep water red crab *(Geryon quinquedens)* in the Gulf of Guinea (Cayré *et al.*, 1979). This species, highly appreciated by consumers, exists all along the West African continental slope at depths of between 300 and 700 metres. It is abundant in Angola where it is the object of quite a considerable fishery (Dias and Machado, 1973). Le Loeuff *et al.* (1974), Intès *et al.* (1976), Le Loeuff *et al.* (being printed) mention yields of between 1.6 kg/pot/six hours and 5/kg/pot/12 hours off Ivory Coast. Cayré (1976a) gives yields of 5.3 kg/pot/12 hours for the Congo. This crab is also present off-shore from Senegal between 300 and 600 metres; yields obtained with a trawl of 32 metres of headline have reached 31 kg/30 minutes of fishery. The species keeps better when it is caught in pots, as the gills are not then dirtied by the mud. This fishery could be carried out, where the plateau is not too wide, with the help of small units of around 15 metres of the longline "cordier" type, for which it offers a complementary activity to the longline fishery. Trials on profitability have to be investigated, by combining all the various types of possible fisheries: trawl line fishery (hake, benthic shark *(Centrophorus* spp.), etc.), cuttlefish fishery, crab fishery in pots, etc.

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ATTACHMENT 1

Relationship between catch, effort and catch per unit effort (cpue) for all demersal fish in the Cape Verde (littoral) division; cpue of Polish trawlers, 5.53 GRT type

Year	cpue (tons/fishing day)	Total catch[1] (thousand tons)	Calculated effort (fishing days)	Average effort $\frac{\text{Year n + Year n-1}}{2}$
1965	14.2	66.6	4 690	
1966	13.3	65.2	4 902	4 796
1967	13.9	77.1	5 547	5 224
1968	10.5	95.7	9 114	7 330
1969	7.4	117.7	15 905	12 509
1970	6.7	123.8	18 478	17 191
1971	6.2	160.2	25 838	22 158
1972	7.0	179.6	25 657	22 747

[1] Source: See Table 3

$$\log e \frac{Y_E}{f_E} = 2.7161 - 0.00041 f_E$$

f_{MSY} = 24 390 fishing days

MSY = 136 000 tons

ATTACHMENT 2

Relationship between catch, effort and catch per unit effort (cpue) for all demersal fish in the Cape Verde (littoral) division; cpue of Japanese trawlers

Year	cpue (kg/hour of fishing	Total catch[1] (thousand tons)	Calculated effort (thousand hours)	Average effort $\frac{\text{Year n + Year n-1}}{2}$
1964	1 482	69.1	46.6	
1965	977	66.6	68.2	57.4
1966	867	65.2	75.2	71.7
1967	1 113	77.1	69.3	72.2
1968	789	95.7	121.3	95.3
1969	703	117.7	167.4	144.3
1970	486	123.8	254.7	211.0
1971	465	160.2	344.5	299.6
1972	881	179.6	203.8	191.7
1973	831	223.2	268.6	236.2
1974	870	230.2	264.6	266.6

[1] Source: See Table 3

$$\frac{Y_E}{f_E} = 1\,154.2 - 2.1627\, f_E$$

f_{MSY} = 267 000 hours of fishing

MSY $\simeq$ 154 000 tons

ATTACHMENT 3

Relationship between catch, effort and catch per unit effort (cpue) for sparids in the Cape Verde (littoral) division

Year	cpue[1] (kg/hour of fishing)	Total catch[2] (thousand tons)	Calculated effort (thousand hours)	Average effort $\frac{\text{Year n + Year n-1}}{2}$
1964	361	41.1	113.8	
1965	387	37.9	97.9	105.8
1966	428	36.7	85.7	91.8
1967	438	31.8	72.6	79.1
1968	417	30.1	72.2	72.4
1969	376	38.6	102.7	87.5
1970	142	47.7	335.9	219.3
1971	126	58.4	463.5	399.7
1972	340	61.0	179.4	321.4
1973	587	73.6	125.4	152.4
1974	392	55.5	141.6	133.5

[1] Type 5.53 GRT Japanese trawlers

[2] Source: CECAF Statistical Bulletin (FAO, 1976)

$$\frac{Y_E}{f_E} = 565.8 - 1.2189\ f_E$$

F_{MSY} = 232 000 hours of fishing

MSY $\simeq$ 66 000 tons

ATTACHMENT 4

Relationship between catch, effort and catch per unit effort (cpue) for all demersal fish on the Nigerian shelf (1964-1969)

Year	cpue[1] (kg/hour of fishing)	Total catch[2] (thousand tons)	Calculated effort (thousand hours)	Average effort $\frac{\text{Year n + Year n-1}}{2}$
1964	75	20.8	277.3	
1965	50	20.0	400.0	338.7
1966	45	22.0	488.9	444.5
1967	43	25.7	597.6	543.2
1968	34	27.3	802.9	700.2
1969	37	21.7	586.4	694.6

[1] Type 11 GRT Nigerian trawlers

[2] Source: CECAF Statistical Bulletin (FAO, 1976)

$$\frac{Y_E}{f_E} = 63{,}8 - 0{,}0405\ f_E$$

f_{MSY} = 788 000 hours of fishing

MSY $\simeq$ 25 000 tons

CHAPTER IV

PINK SHRIMP RESOURCES

(Penaeus duorarum notialis)

by

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1. INTRODUCTION

Four penaeidae shrimp species are found along the coast of West Africa: *Penaeus kerathurus, Parapenaeopsis atlantica, Penaeus duorarum* and *Parapenaeus longirostris.*

Population densities of the first,an inshore species,found everywhere along the coast, are not such as to warrant its specialized exploitation.

The second is also an inshore species. Bound to the warm, relatively salt-free waters of the surface, it is not generally considered to be abundant. Because of this and also because of its poor keeping qualities, it makes up an insignificant portion of landings, and indeed is often thrown back. It should be noted however that this as yet little known, little studied species appears to be subject to intense, interannual population fluctuations. Though yields are customarily low, as much as two tons/day have been caught in October-November 1974 near the mouth of the Comoé in flood (Ivory Coast).

Parapenaeus longirostris can be found below 45 metres in certain areas (Ivory Coast during the cool season) and as far down as 350-400 metres. The species is fished on a more or less regular basis by Spanish vessels off Senegal, Angola and Congo, at the same time as *Aristeus varidens* and *Plesiopenaeus edwardsianus.* In 1968 yields fluctuated between one to two tons/day for 30-50 metre boats (Crosnier and Tanter, 1968).

Penaeus duorarum is presently the most heavily fished species, making up the bulk of landings. It is caught in lagoons or rivers during the juvenile phase. A traditional fishery in Ghana and Nigeria, and since 1959 also fished in Senegal, exploitation at sea by specialized shrimpers began in Senegal and Nigeria in 1965 and spread to the entire Gulf of Guinea between 1965 and 1970. This species was formerly a mere by-catch of coastal trawlers specializing in fish usually concentrated at lesser depths than those at which *Penaeus duorarum* is most abundant.

The purpose of this study is to assess the potential yield of the various fishing grounds of the Gulf of Guinea. Available catch and effort statistics, as well as the amount of work done on assessing the various stocks of *Penaeus duorarum,* vary wildly from one sector to the next. Most of the data used in this report are from the files of the oceanographic research institutes of Abidjan (Ivory Coast) and Dakar-Thiaroye (Senegal), the Statistical Bulletin of CECAF, and the literature. It has been possible to reconstruct landings in Nigeria as of 1967 and in Cameroon as of 1966. Exact data of the fishing effort (standardized units) and the population structure of the catches are available only for the Senegalese and Ivorian fleets.

Since the statistical data were often highly imperfect, we have resorted to extrapolations and to suppositions based on the experience of fisheries in the region. Considering the kind of data available, the following method of assessment was retained: optimum effort and corresponding catch1/ were calculated from chronological series of catch and effort available for the better known fishing grounds, using Fox's exponential model. Knowing the area of the different fishing grounds, actual mean optimum yield (per sq. mile per year) and the corresponding fishing intensities were calculated. By extrapolating these answers to the whole of the exploitable area of each statistical division, a first approximation was obtained of the potential yield of each division. This method is based on the assumption that nearby

---

1/ For economic and even biological reasons, the maximum sustainable yield (MSY) is not a satisfactory objective. We therefore preferred to calculate yield in terms of optimum effort, using Gulland and Boerema's (1973) definition of optimum as the point at which marginal yield equals 10 per cent of the cpue recorded at the time the fishery was launched fishing grounds with similar hydroclimatic and exploitation patterns have potential yields approximately proportionate to their area. Hopefully, the risk of bias having to do with possible differences in productivity among the various ecosystems can be substantially reduced by limiting the scope of the extrapolations to each statistical division. It will be recalled that the CECAF statistical divisions were in fact so drawn up as to correspond to the major hydrological units of the region (see Chapter I, Hydrology Review). Differences in the productivity of the different regions are analysed at the end of this work. Clearly, the area of the fishing grounds at sea is not the only factor determining potential stocks. A strict estimation ought to have taken the nurseries, among other things, into account. Unfortunately, this datum is even more difficult to pinpoint than the area of the fishing grounds.

The problem of defining the boundaries of the fishing grounds (Fig. 1) was approached as follows. Garcia's 1976 surveys in Ivory Coast showed the exploitable concentrations at depths of 20-60 metres over bottoms containing more than 75 per cent fine sediment. Domain (1977) confirms this observation for the Saint-Louis (Senegal) and Roxo-Bissagos grounds. In general all authors agree that the important concentrations are found over sandy-mud bottoms. We therefore used these granulometric criteria, where available, to calculate the area of exploitable grounds. Where the granulometry of the grounds was not known, we used the boundary limits recognized by shrimper skippers, having first checked to see whether these limits did not simply correspond to political boundaries. Burukowski and Bulanenkov's 1969 work was an excellent source of documentation.

2. REVIEW OF THE BIOLOGY OF THE SPECIES

The findings summarized in this chapter are mostly taken from Garcia's 1976 survey on the Ivory Coast stocks. A more complete bibliography of the literature on this species and more detailed information on its biology can be found in this work.

2.1 Ecology and Distribution of Adults

Penaeus duorarum is found along the West Atlantic coast from Cape Hatteras (USA) to Cape Frio (Brazil) and on the eastern side from Cape Blanc (Mauritania) as far South as Angola (Pérez-Farfante, 1969). On either side of the Atlantic, *Penaeus duorarum* covers a geographical area within which surface temperatures rise at least as high as 24°C during the year and rarely drop below 18°C. Minimum bottom temperatures are about 15-16°C. This might be connected with the shrimp's metabolic requirements, especially those concerning reproductive mechanisms.

Within these thermal boundaries, the distribution of adults is determined by salinities of more than 35‰. In hydrologically suitable areas, distribution has to do with the presence of lagoons or estuaries and to the nature of the sediment of the continental shelf over which the adults make their home. One important characteristic of shrimping grounds at sea is their great wealth of organic matter. The bathymetric distribution of the species is linked to the structure of the sediment. Important concentrations are found where sediment content is +50 per cent. The lower limit of distribution, roughly 60-65 metres, is in all likelihood ecological in nature.

In the alternance zones where the depth of the thermocline fluctuates with the seasons, the distribution of *Penaeus duorarum* corresponds to areas where the fine particles content ($\leq$ 50 μ) is more than 50 per cent. Bathymetric distribution varies with these fluctuations. The displacements tend to maintain the shrimp at a level above the discontinuity layer, between 23° and 25°C on the one hand and between 35° and 35.5‰ on the other. During the upwelling season, these waters disappear from the continental shelf and the shrimp are then forced to put up with locally less optimum conditions (16°-18°C).

Bathymetric distributions by size and sex are highly characteristic, and are different from those observed in the Gulf of Mexico. Small and medium-sized shrimp make their home in the central depths of the distribution area (30-45 metres). This is the most abundant group. Their sex/ratio is close to the norm. Average size increases and abundance drops off out to

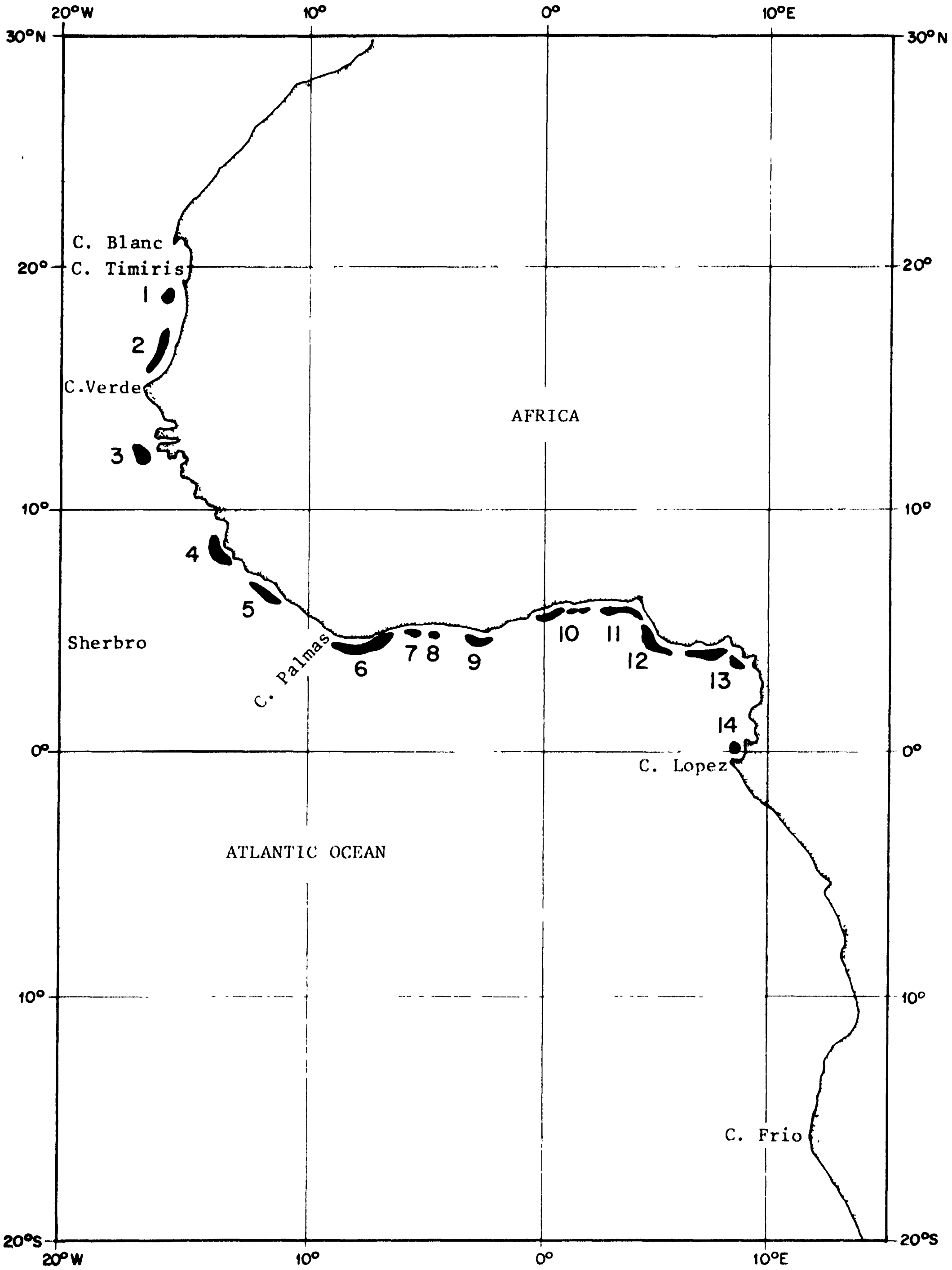


Figure 1 - Main fishing grounds and CECAF statistical divisions 1: Cape Timiris; 2: St-Louis of Senegal; 3: Roxo-Bissagos; 4: Sherbro; 5: Monrovia; 6: Sassandra-Tabou; 7: Grand-Lahou; 8: Grand-Bassam; 9: Axim-three points ; 10: Adda-Keta; 11: Lagos; 12: Niger delta; 13: Cameroon; 14: Cape Estérias

sea (where males dominate) and shoreward (where females dominate). The bathymetric distribution of the sexes changes seasonally, in all likelihood in connexion with reproduction. Off the Niger delta, however, the highest yields are obtained at the shallowest depths fished (roughly 20-25 metres) (Fig. 2).

2.2 Behaviour and Yields

The highest yields of the coast of Africa are registered either at night or during the daytime, or either one. This "apparent" behaviour depends on the area, time of year and depth under consideration. It is accepted that shrimp are more active at night and that the "apparent" behaviour is only a manifestation of nycthemeral modifications in the vulnerability of shrimp. These modifications, connected with the water turbidity, are thought to be caused by vertical migrations which take the shrimp periodically out of the reach of the trawling nets. Results obtained in the Senegal-Gambia area suggest that this pattern of behaviour is modified by the water temperature during the cool season.

2.3 Reproduction and Larval Migration

The proportion of mature females in the catch rises in Ivory Coast starting in October when the waters begin to warm up again after the cool season. Proportions are high from October to December and decrease irregularly until May-June, when there is sometimes a secondary maximum.

The larvae penetrate very soon after spawning, which takes place at sea, into the lagoons or estuaries. The abundance of postlarvae on the surface at the entrances to the lagoons follows nycthemeral, lunar and seasonal rhythms. Larvae are present only at night. The nocturnal abundance curve is unimodal or bimodal according to the phase of the moon and the tidal cycle. Global abundance is determined by the phase of the moon, with peaks at new moon and troughs at full moon. At the half-moon, abundance is also at the halfway point. These fluctuations reflect the effect of either a lunar spawning cycle, or, more likely, the effect of tidal rhythms interacting with moonlight, which would bring about a drop in the abundance of larvae on the surface at full moon.

Postlarval sizes, at equal stages of development, fluctuate seasonally in line with the abundance of plankton in the sea and in inverse ratio to water temperature.

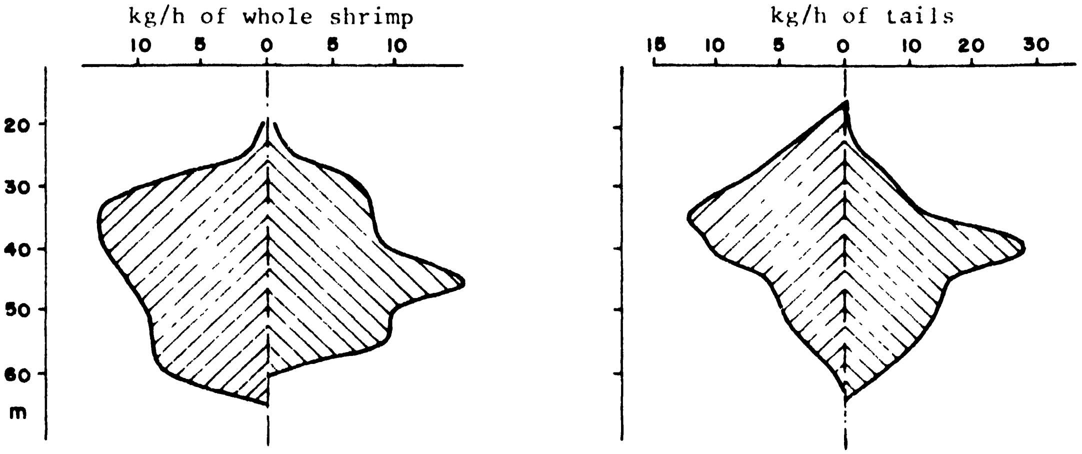
2.4 Migration of Juveniles

Migration takes place at an age of 3-4 months, after a 2.5-3 month period in lagoons. It follows a nycthemeral and tidal rhythm. Migration occurs at night when the tide is falling. Seasonal variations of the amplitude of migration are obviously connected with the reproductive cycle and the external factors which govern it. Migration peaks occur when the rivers are in flood and currents strong, lowering the saline content of the water.

The boundaries of the horizontal distribution of juveniles in lagoons are determined by the sea's influence (tidal currents, inflow of salty waters). Size at migration fluctuates seasonally, depending on the region. In Ivory Coast the (cephalothoracic) length is 16-17 mm. The mean figure for Nigeria is just a little smaller. Size at migration also fluctuates for different parts of the same lagoon and from one lagoon to the next according to salinity. It also varies from year to year in the same lagoon according to rainfall - here also salinity is the determining factor. It is thought that salinity acts on size at migration by shortening the length of stay in the lagoon when salinity drops.

2.5 Recruitment and Sexual Maturity

The recruitment of juveniles into the sea, estimated from the percentage of small-sized specimens (LC ≤ 22 mm) in hauls, is very closely bound up with the mean annual migration curve from lagoons. By comparing mean annual spawning, migration and recruitment cycles, it was possible to reconstruct the time sequence of the life cycle (Fig. 3). Whilst the postlarvae are at least three weeks old when they work their way into the lagoons at the stage of 3-4 rostral spines, the grand migration takes place at age 3-4 months when the shrimp are 16-17 mm



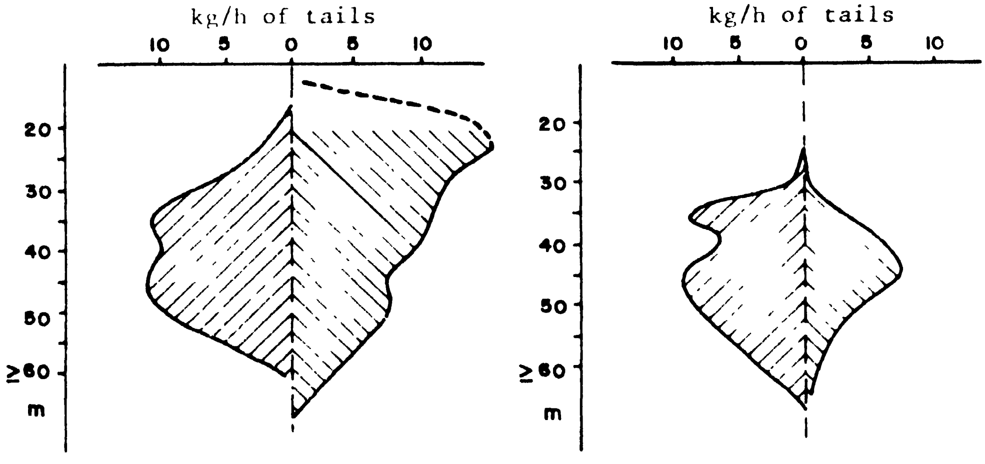
1966-67 1969-70

GRAND BASSAM transect

OCT.1969 to SEPT.1970

SASSANDRA TABOU

IVORY COAST



15/3 to 31/12-1970 15/12-70 to 31/8-71 SEPT. OCT.1970 15/9/70 to 15/3/71

GHANA NIGERIA TOGO BENIN

Figure 2 - Bathymetric distribution of yields from the Abidjan based fleet, in various sectors of the Gulf of Guinea (from Garcia, 1977).

long (LC). The first modes (18 mm LC) in length frequency distributions of catches at sea correspond to specimens four months old. The interval between migration and recruitment into the marine fishery is therefore very short. Size at earliest maturity (30 mm LC in Ivory Coast, 27 mm LC in Senegal) is reached approximately at 6-7 months. Life expectancy is at least 23 months.

2.6 Growth

Various methods have been used to study growth - one is tagging. All findings point to a single conclusion. Growth is rapid in the hot season and very disturbed during the cool season as well as, apparently, during spawning. No meaningful difference has been discerned between mean annual growth figures recorded on either side of the Atlantic.

2.7 Mortality

Tagging has made it possible to evaluate natural mortality ($M = 0.25$ on a monthly basis), fishing mortality and the catchability coefficient ($q = 0.00069$). Taggings have clearly revealed fluctuations in recapture rates as linked with age. The utilization of simulation techniques based on a Ricker model suggests the existence of seasonal fluctuations of catchability. An analysis of the demographic structures of annual catches at different levels of fishing intensities confirms the scale of natural mortality (21 months), the global catchability coefficient ($q = 0.00063$) and seasonal catchability fluctuations (Garcia, 1977a).

3. FISHING METHODS

During their life cycle, which evolves from the brackish lagoons or estuaries to the inshore coastal waters, shrimp are fished at two different times: first as juveniles by artisanal fishermen and again at the pre-adult and adult stage by industrial fishermen.

3.1 Artisanal Fisheries

Artisanal fishing takes place primarily during the migrations of juveniles from their brackish habitat seaward, at about three months. The passages are cut off with closely grouped set nets, which are normally put in place at night, at ebb tide. Another, less common, method is used in areas where there is no strong current. This is the skimming net method. The fishermen push the net before them, and it acts as a trawl would. This kind of fishing nets the younger specimens which have not yet completed their growth in brackish waters.

Shrimp fishing, a tradition in certain countries such as Benin and Senegal, spread under the stimulus of the shrimp industry to include the entire coastal sector. Industry has frequently assumed responsibility for the initial expenditure for gear, as well as organizing pick-up and export marketing of the catch. Artisanal fishermen generally get a higher income from this activity than they could from other kinds of fishing. In countries where factories pick up the landings (Senegal, Ivory Coast, etc.) good statistical information is usually available. Elsewhere catch statistics and other parameters for this fishery are still sketchy.

Artisanal fisheries are important mostly in Senegal, Ivory Coast and Nigeria.

3.2 Industrial Fisheries

Industrial fishing, a maritime activity, begins soon after the arrival of the 4-5 month old shrimp at the fishing grounds (Fig. 3). These specimens have not yet attained sexual maturity, which occurs at around 6-7 months. The usual shrimpers are average-sized trawlers (20-30 metres). Since 1968-1970 almost all employ the Florida double rigging (simultaneous hauling of two trawls with a 14-20 metre headrope). The use of the testing net to locate heavy concentrations more rapidly is not commonly used by European skippers - but is apparently much more so by skippers from the Gulf of Mexico area.

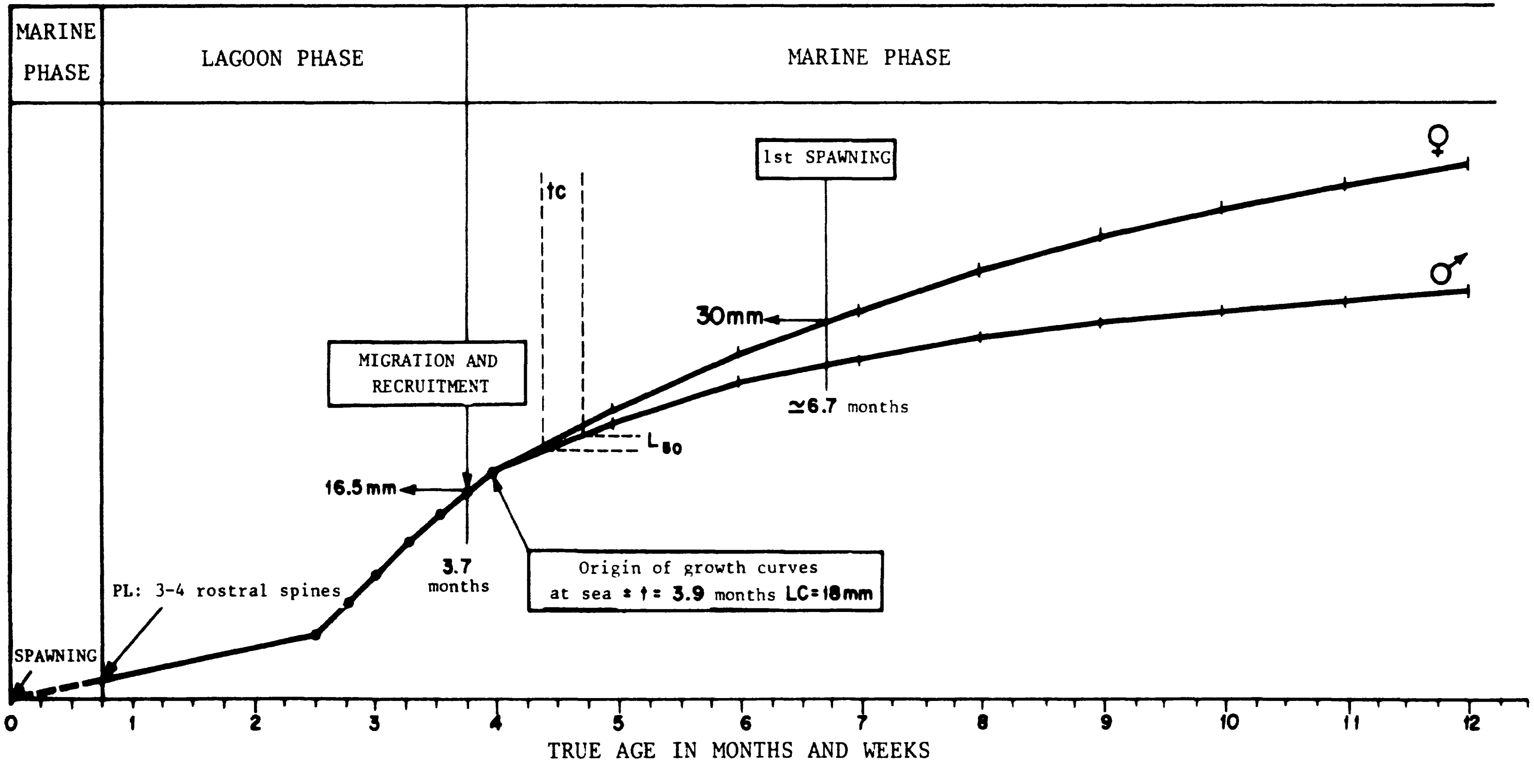


Figure 3 - Reconstitution of the life cycle chronology (t_c = age at first capture) (from Garcia, 1977).

The vessels keep their catches on ice or frozen. They remain at sea for one week or one month according to the kind of catch preservation available. Actual trawling time ranges 12-18 hours/day according to whether or not the initial daytime fishing is followed by a night-time stint.

Depending on the market for which the shrimp are intended (Europe or USA/Japan), they are kept with heads on or as tails. Ice-boats usually treat the shrimp with bisulphite to avoid blackening. On modern freezer-ships they are sorted and packaged on board. The major fishing grounds are off Senegal, Guinea Bissau, Sierra Leone, Liberia and Nigeria.

4. ASSESSMENTS

Assessments were made separately for each of the five CECAF statistical divisions where *Penaeus duorarum* is found in appreciable amounts.

4.1 Cape Verde (littoral) Division

This division extends from Cape Timiris to the Sherbro Islands. It is off Mauritania, Senegal, Gambia, Guinea Bissau, Guinea and Sierra Leone. The following fishing grounds are located there:

- the Cape Timiris grounds (30-40 mi^2). It appears to be fed by the nurseries of the Arguin banks;

- Saint-Louis du Sénégal (350 mi^2), from latitude 16°10' N to 15°10' N. It corresponds to the Senegal River nurseries;

- the Roxo-Bissagos grounds which run from the mouth of the Casamance to the Geba River, or from 12°20' N to 11°35' N (an area of 200-250 mi^2). It is fed by the nurseries of the Sine-Saloum (this assumption needs checking), Gambia, Casamance, Cacheu and Geba Rivers.

These grounds are worked exclusively and regularly by the Senegalese fleet. Mauritian and Soviet vessels have conducted exploratory surveys on occasion. Juveniles are fished on an artisanal basis in the Senegal, Gambia, Sine-Saloum, and especially the Casamance Rivers. The 1974 yields (not counting discards on which there are no present data) exceeded 2 000 tons[1/].

Table 1 lists the available data. Total catches rose from 131 tons in 1960 to 5 540 tons in 1975. An analysis of the catch and effort time series produced the following estimates (Garcia and Lhomme, 1977).

4.1.1 Saint-Louis du Sénégal stocks (Fig. 4)

These grounds have been fished since 1965. The effort has increased from $1.9\text{-}57.0 \cdot 10^3$ actual trawling hours, by shrimpers with 350 hp of motor power. The mean optimum yield has been assessed at 570 tons for an effort of $53 \cdot 10^3$ fishing hours. This finding corresponds to a mean optimum productivity of 1.6 tons/mi^2 obtained at fishing intensities of 150 h/mi^2/year.

Artisanal fishing presently accounts for less than 200 additional tons each year.

[1/] This official figure is in all likelihood an overestimation. The true figure is probably more in the neighbourhood of 1 500 tons (Le Reste, pers. comm.)

4.1.2 Roxo-Bissagos stocks (Fig. 5)

These stocks have been exploited since 1966. Effort has increased from 2 to $150 \cdot 10^3$ fishing hours. Mean optimum yield is assessed at 2 350 tons, with an estimated effort of $183 \cdot 10^3$ hours. The corresponding mean productivity ranges between 9.4 and 11.8 tons/mi^2/yea at fishing intensities of 730 to 920 h/mi^2/year.

If we accept the proposition that all nearby rivers contribute to the production of juveniles, the additional offtake from artisanal fishing during the period under study would average about 150 tons for the Sine-Saloum, 1 500 tons for the Casamance, and 400 tons for the Gambia, or a total figure of something over 2 000 tons/year.

4.1.3 Cape Timiris stocks

To the best of our knowledge, this stock has never been fished on a regular basis. Should its productivity be similar to that of the Saint-Louis du Sénégal grounds, the maximum sustainable yield would be 60 tons/year, or thereabouts.

In conclusion, under the prevailing conditions of exploitation in this division, and especially in the light of the present offtake of juveniles by artisanal fishermen, the mean optimum yield for the Cape Verde (inshore) division would be approximately 3 000 tons/year at sea. This figure is joined by the current artisanal yield (assumed to be steady), which is estimated to be equal to the mean over the last four years, i.e., 2 250 tons/year. The total yield for this division would therefore be about 5 200 tons. Catches exceeded this figure slightly in 1974 (5 268 tons) and 1975 (5 540 tons), but not in 1976 (4 130 tons).

As for the relative levels of exploitation of the various grounds, the Saint-Louis level is thought to be close to the just defined optimum ($\bar{f}_{74-76}/f_{opt} = 0.98$) whereas exploitation of the Roxo-Bissagos grounds is slightly under this level ($\bar{f}_{74-76}/f_{opt} = 0.76$).

4.2 Sherbro Division (Fig. 6)

This division extends from the Sherbro Islands to Cap des Palmes and includes a portion of the Sierra Leone and Liberian coasts. This sector is exploited fairly regularly by shrimpers based in Senegal and Liberia. It is also occasionally visited by the Abidjan-based fleet. The main fishing grounds are located:

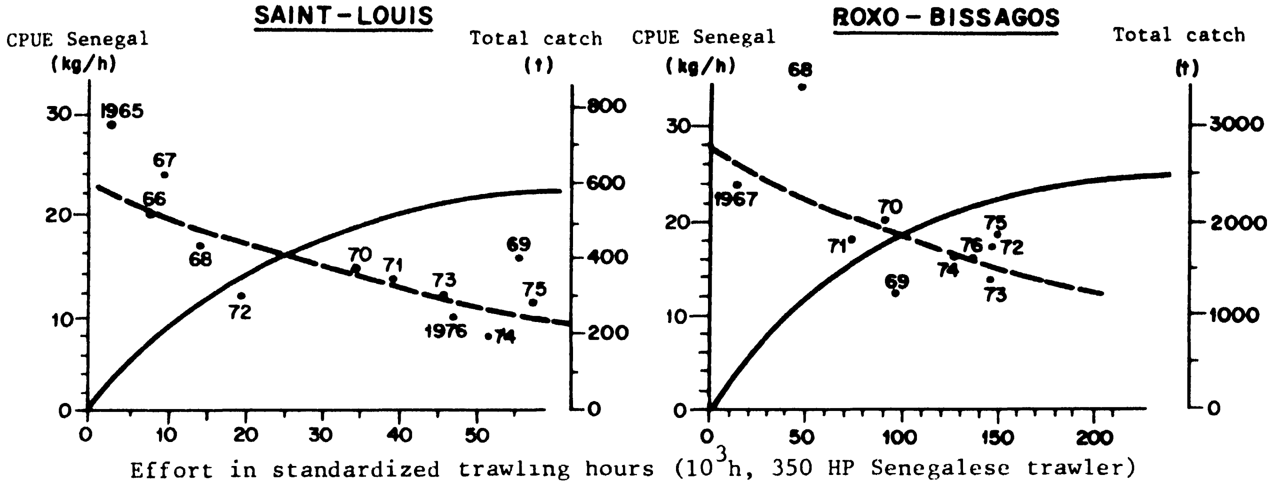
- between the Sherbro Islands and Cape Mount (200 mi^2),
- between Cape Mount and Cape Monrovia (150 mi^2),
- and west of Cap des Palmes, in the extension of the Ivorian fishing grounds of Sassandra-Tabou (50 mi^2).

The total area for this sector is therefore 400 mi^2.

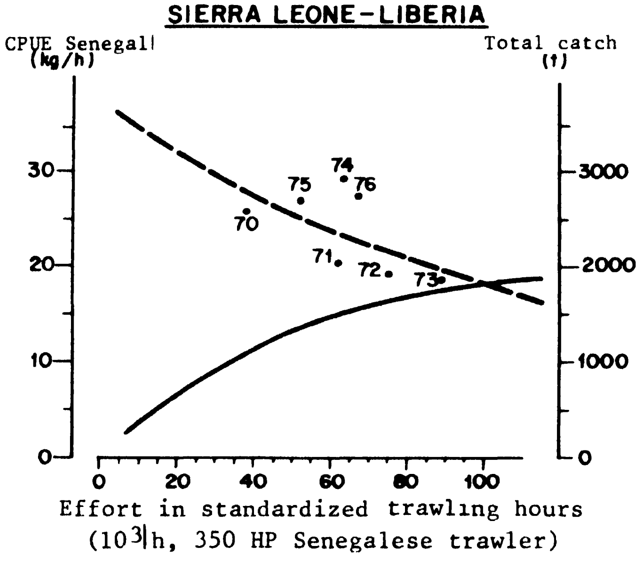
Table 1 lists the available statistics. From 1969 to 1976 total catches at sea fluctuated between 505 tons and 1 854 tons. Total catches and standardized efforts of the Senegalese fleet for the period 1969-1976 are available (Table 4). The 1969 figures, corresponding to the starting period in this sector, give an obviously underestimated abundance index. For this reason it was not taken into account in making the assessments.

The estimate of the total effort in this sector from 1969 to 1975 was based on the total catch and Senegalese cpue. Applying these data to Fox's model, we got the following estimations (Fig. 6 - Table 4):

- mean optimum yield: 1 800 tons;
- corresponding effort: $104.10 \cdot 10^3$ fishing hours, a figure representing a mean productivity of 4.5 tons/mi^2/year at fishing intensities of 260 trawling h/mi^2/year.



Figures 4 and 5 - Cape Verde (littoral) division: production models obtained for the St-Louis and Roxo-Bissagos stocks (1965-1976) (from Garcia and Lhomme, 1977) from the cpue of the Senegalese fleet.



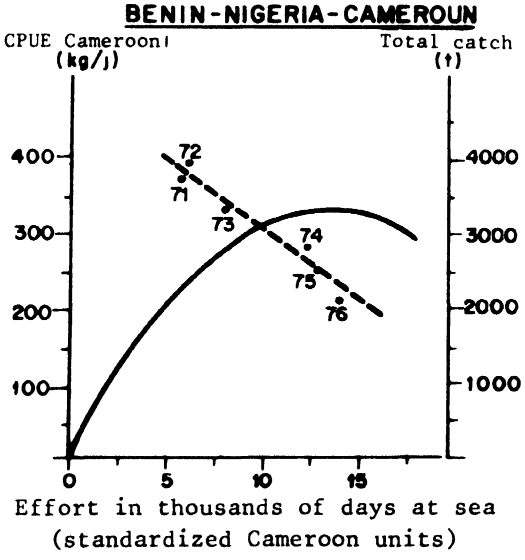


Figure 6 - Sherbro division: production model for the Sierra Leone-Liberia stock from cpue of the Senegalese fleet (from Garcia and Lhomme, 1977)

Figure 7 - Gulf of Guinea (centre): Production model for the Benin-Nigeria-Cameroon stock (from FAO, 1978).

Table 1 – Annual shrimp *(Penaeus duorarum)* catch by country, fisherman and CECAF statistical division

CECAF Statistical Division	YEAR 1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
CAPE VERDE (Inshore)																
Mauritania	0	0	0	0	0	0	0	0	0	...	...	...	...	...	...	...
Senegal	131	254	387	455	592	833	881	1362	2840	3483	3242	2844	4384	3959	4868	5140
Gambi	0	0	0	0	0	0	0	0	0	0	0	63	88	260- 400(a)	183- 400(a)	400(a)
Guinea Bissau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USSR	...	...	...	...	500	...	...	...	...	...	...	...	...	...	...	...
TOTAL	131	254	387	455	1092	833	881	1362	2840	3483	3242	2907	4472	4359	5268	5540
SHERBRO																
Senegal	0	0	0	0	0	0	0	0	0	89	179	637	640	318	425	143
Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liberia	0	0	0	0	0	0	30	0	6	(400)	(750)	(630)	(800)	1300	1429	1228
Ivory Coast	...	...	...	...	...	...	...	...	...	16	18	4	0	0	0	17
USSR	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0
TOTAL	...	...	...	...	...	...	...	...	...	505	1047	1271	1440	1618	1854	1388
GULF OF GUINEA (West)																
Ivory Coast	155	120	115	(190)	260	270	260	490	630	830	1100	1350	960	980	910	1170
Ghana (b)	0	0	0	0	0	443	0	240	250	610	470	470	600	790	1420	740
Togo									Negligible catches							
Benin	...	...	...	...	...	...	270	320	...	...	...	...	...	...	...	...
TOTAL	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
GULF OF GUINEA (Central) (34.3.5)																
Ivory Coast	0	0	0	0	0	0	0	0	0	0	2	117	227	129	6	0
Benin	...	...	...	...	...	...	...	...	...	...	3	47	218	467	502	237
Nigeria (d)	...	16	...	...	...	...	...	750	550	(731)	912	1345	1245	1358	2021	2139
Cameroon	...	...	...	...	...	...	50	50	(100)	257	295(c)	859	1018	972	1114	1001
TOTAL	...	...	...	...	...	...	(50)	(800)	(650)	(988)	(1210)	2368	2708	2926	3643	3377

(a) Official figures correspond to those declared (CECAF Statistical Bulletin). The second figure, marked with an asterisk, in an unofficial estimate of the true catch. Figures in parentheses are estimates or interpolations

(b) These figures actually concern a mixed population made up mainly of *Parapenaeopsis atlantica*

(c) Incomplete data

(d) Lagoon catches not taken into account

Table 2 – Cape Verde (inshore) division: Catches, efforts (fishing hours for a 350 hp trawler), and cpue (kg/h of fishing) of the Senegalese fleet on the Saint-Louis and Roxo-Bissagos stocks from 1965-1975

Fishing grounds	SAINT-LOUIS			ROXO-BISSAGOS		
Year	Effort (10^3h)	Catch (tons)	cpue (kg/h)	Effort (10^3h)	Catch (tons)	cpue (kg/h)
1965	1.9	55	28.9	-	-	-
1966	7.1	143	20.1	1.6	6	3.7
1967	9.0	218	24.2	14.9	358	24.0
1968	13.7	227	16.6	49.5	1 700	33.3
1969	55.0	896	16.3	96.8	1 205	12.4
1970	33·9	486	14·3	91·8	1 826	19·9
1971	38·7	532	13·7	73·9	1 322	17·9
1972	19·6	224	11·4	145·6	2 529	17·4
1973	45·6	540	11·8	146·3	1 768	12·1
1974	51·3	405	7·9	131·1	2 096	16·0
1975	57·0	617	10·8	150·0	2 814	18·8
1976	47·2	464	9·8	138·0	2 168	15·7

Table 3 – Cape Verde (inshore) division: Yield in tons of artisanal fishing from 1960-1975 in Senegal

Year	River			TOTAL
	Senegal	Sine-Saloum	Casamance	
1960	7	0	124	131
1961	21	50	183	254
1962	35	100	252	387
1963	21	61	373	455
1964	21	61	504	586
1965	7	22	749	778
1966	10	117	611	738
1967	28	196	562	786
1968	8	192	713	913
1969	13	93	1 274	1 380
1970	10	67	853	930
1971	55	124	811	990
1972	260	104	1 267	1 631
1973	127	36	1 488	1 651
1974	267	83	2 017 1/	2 367
1975	122	307	1 280	1 709
1976	99	0	996	1 095

1/ Doubtless overestimated, real figure in all likelihood closer to 1 500 tons (Le Reste, pers. comm.)

Table 4 - Sherbro division: Catches and efforts (in total fishing hours) and cpue of the Senegalese fleet off Sierra Leone (Source: Garcia and Lhomme, 1977)

Year	Effort (10^3h)	Catch (tons)	cpue (kg/h)
1968	0	0	0
1969	43.5	505	11.6
1970	37.7	947	25.7
1971	61.4	1 271	20.7
1972	75.0	1 440	19.2
1973	88.4	1 618	18.3
1974	63.3	1 854	29.3
1975	51.4	1 388	27.0
1976	66.8	1 836	27.5

Table 5 - Gulf of Guinea (western) division: Changing pattern of total estimated catch (at sea and in lagoons) in Ivory Coast. (For 1955-1969, catches include a very small proportion of shrimp of different species.)

Year	Sea	Lagoon	TOTAL	Year	Sea	Lagoon	TOTAL
1955	15	100 1/	115	1967	170	320 2/	490
1956	20	100	120	1968	?	340	?
1957	20	100	120	1969	490	290	780
1958	35	100	135	1970	620	310	930
1959	90	100	190	1971	710	620	1 330
1960	55	100	155	1972	480	480	960
1961	20	100	120	1973	460	520	980
1962	15	100	115	1974	280	630	910
1963	?	100	?	1975	390	780	1 170
1964	160	100	260	1976	480	630	1 110
1965	150	100	250	1977	460	620	1 080
1966	160	100	260				

1/ Estimated figure

2/ Beginning of the industrialization of lagoon fishing

The current relative level of exploitation ($\bar{f}_{74-76}/f_{opt}$) is 0.58. A substantial increase should therefore be quite possible.

There are no data available on artisanal fishing in this sector. It certainly exists, and the potential figure of 1 800 tons should be considered the minimum figure. However, it is rather unlikely that the artisanal yield exceeds 20 per cent of this figure, or 340 tons.

4.3 Gulf of Guinea (western) Division

This division extends from Cap des Palmes to the Benin-Nigeria boundary. It runs along the coasts of Ivory Coast, Ghana, Togo and Benin. The sector is regularly worked by the Ivorian fleet and, from time to time, by the Ghanaean fleet. The Liberian fleet probably fishes the western-most part of the sector on occasion (Cap des Palmes-Tabou), and the Nigerian fleet probably operates in the eastern side at times. Benin has had a fleet of at least five shrimpers since 1973, but no data are available on performance of this fleet.

The main fishing grounds in Ivory Coast are located between Tabou and Sassandra (250 mi^2), off Grand-Lahou (80 mi^2) and off Grand-Bassam (60 mi^2). In Ghana they are located off Axim (120 mi^2) and Adda-Keta (80 mi^2). The exploitable fishing ground area is 90 mi^2 off Togo and 180 mi^2 off Benin. The total area of this sector is 860 mi^2.

The most complete study is that made in Ivory Coast, for which reliable catch and effort statistics date back to 1969, which is when specialized shrimp fishing really began there (Garcia, 1977). With the combined use of a yield model and a Ricker model simulating techniques, we were able to assess the Ivorian stock potential at 1 260 tons assuming a total lack of artisanal fishing and a critical effort of 2 810 standardized fishing-days (250 hp trawlers). Mean productivity would be 3.2 tons/mi^2/year at fishing intensities of 7.2 fishing days/mi^2/year (Garcia, 1978).

If we add on the rate of exploitation developed in artisanal fishing by the year 1975, when 55 per cent of the shrimp were caught before migrating out to sea, then the maximum sustainable yield at sea becomes 570 tons and the lagoon catch about 600-700 tons.

The Gulf of Guinea (western) division is hydrologically and climatically homogeneous. Due to the presence of seasonal upwelling in the western part of the sector (Ghana, Ivory Coast), it may well be more productive than the eastern part (Togo, Benin). Extrapolating the Ivory Coast findings to the entire division based on the above estimated maximum sustainable yield, we get a global maximum sustainable yield for the entire sector of 2 750 tons/year. The corresponding effort would be 6 200 standardized fishing-days (250 hp) yearly. The extrapolation is based on a theoretical catch at sea and no artisanal lagoon fishing whatsoever.

Concerning the respective level of exploitation of the Ivorian grounds, the offtake is currently somewhat below the MSY of these grounds, at a level which is thought to be close to the economic optimum. The available data on present and potential catches in the other sectors are so scant and unreliable as to make it impossible to advance any hypothesis on them. In addition, the recent closing of the Ghana lagoons will most likely result in a drastic reduction of the potential of this sector.

4.4 Gulf of Guinea (central) Division

This division is off the coasts of Nigeria and Cameroon. Shrimp are found in an unbroken inshore strip all along the coast. According to Raitt and Niven (1965), the exploitable area in Nigeria would cover 2 500 mi^2. This figure is also given by Thomas (1969). Burukowski and Bulanenkov (1969), on the other hand, estimate the Nigerian ground at 1 300 mi^2 and the Cameroonian estuary zone at 190 mi^2. Obviously, this uncertainty as to the total area of the fishing grounds in this division reflects on the extrapolations of the potential catch. The sector is regularly fished by the Nigerian and Cameroon based fleets and, from time to time, by the Ivorian fleet. It seems likely that vessels based in Cotonou also derive a part of their catch from this division.

The most important portion of the stock is located around the Niger delta. It is extremely difficult, under the present statistical situation, to make any exact breakdown of catches by fishing grounds. During the *Ad hoc* Meeting of The Working Party on the Exploitation of *Penaeus duorarum notialis* (CECAF, 1978b), the assessment made was a global one on the total shrimp catch in this division.

Landings in 1974,not counting the artisanal fisheries of Nigeria, which can be assessed at 250 tons for the Lagos sector (Obakin, 1970) and 500 tons for the entire estuary system, totalled 3 760 tons (FAO, 1969). Catch and effort statistics for the Nigerian fleet (Bayagbona, 1976) for the years 1970-1976 show the cpue remaining stable whereas effort doubled from 4 000 to 8 000 fishing days. This might mean that the fishery is still in its initial stage of development and that the stock is far from being fully exploited. Or it could also mean that the nominal effort statistics utilized are not providing a proper mortality index from fishing sustained by the stocks. In addition, the author suggests that the efficiency of the fleet must have increased between 1970 and 1974.

In the draft version of this report[1/], we noted that "the mean cpue obtained from 1970 to 1974 is 22 kg/day at sea. This is a low figure compared with the yields obtained at low levels of exploitation on the Saint-Louis grounds (532 kg/day in 1966-1967), and those of Roxo-Bissagos (700 kg/day in 1967-1968), Sierra Leone/Liberia (554 kg/day in 1970-1971), and in Ivory Coast (435 kg/day in 1969). In addition, the recorded yield for recent years in Nigeria is below the cpue for the maximum average catch estimated for the other sectors: 276 kg/day for Saint-Louis, 339 kg/day for Roxo-Bissagos, 380 kg/day in Sierra Leone/Liberia and 367 kg/day in Ivory Coast. Assuming that the average composition of the Nigerian fleet is comparable to that of the other sectors, and taking into account the fact that effort is measured in days at sea and not fishing days, the rectification which needs to be made of the Nigerian cpue is most probably under 30 per cent. This would bring the cpue at most up to the cpue corresponding to the maximum average yield of neighbouring stocks.

"Clearly, the statistics now available for this sector are insufficient for an appraisal of the state of stocks. It is possible that total catches and efforts have not been at all well pinpointed. However, an indirect assessment can be attempted. The general hydrology of the Gulf of Guinea (Longhurst, 1964) indicates that this division, which does not enjoy seasonal upwelling, must be considered less productive than the preceding division (34.3.4). In this case, the sustainable yield figures obtained for division 34.3.4 should lead to a slight overestimation of the maximum sustainable yield or, at the very least, to a maximum estimate. Taking the lowest estimation of the area of the fishing grounds (1 500 mi^2), potential yield would be at most 4 200 tons, which would correspond to an effort of 11 700 standardized days/year and motor power of 250 hp. If this estimation is correct, the trends in catches (Table 1) would lead us to assume that stocks are fully exploited at present. This preliminary conclusion is confirmed by the fact that the present cpue is low and is close to cpue recorded on fishing grounds in neighbouring divisions where the levels of exploitation are close to maximum average yields.

"On the other hand, if the actual area of the fishing grounds were close to the upper estimate of 2 500 mi^2, maximum yield could be as much as 7 600 tons/year (for an effort of 21 000 fishing days). In that case the stock would indeed be underfished at present and the low cpues obtained would still have to be explained."

Recent data from Cameroon on this fishery (CECAF, 1978b) provide interesting and detailed information which makes it possible to update these conclusions. The statistics are given in Table 6.

[1/] FAO Fisheries Circular No. 703, 1977, 28 p.

Table 6 – Gulf of Guinea (centre) division: Available statistics on catches at sea (including Benin); cpue of the Cameroon fleet, and estimation of the total effort (Source FAO/CECAF, 1978)

Year	Number of Cameroonian shrimpers	Catches (tons, at sea, heads on)		Cpue (Cameroon)		Total effort Benin[3]-Nigeria-Cameroon
		Cameroon	Benin-Nigeria-Cameroon	(kg/fish.day)	(t/b/year)	
1966	1	(25)			(25.0)	
1967	1	(50)			(50.0)	
1968	2	(100)			(50.0)	
1969	2-8	257			42.8	
1970	10	295[1]	1 210[1]	260	29.5	
1971	10	859	2 251	379	85.9	5 939
1972	10	1 018	2 481	398	101.8	6 234
1973	13	972	2 796	342	74.8	8 175
1974	17	1 114	3 637	291	65.5	12 498
1975	17	1 001	3 377	267	58.9	12 648
1976	17	882	3 099	222	51.9	13 959
1977	17	831		186[2]	48.9	

( ) Estimate

1/ Partial figure

2/ Extrapolated from figures for first 10 months

3/ In standardized Cameroonian units (kg/fishing day)

Cpues have been dropping since 1971. The yields indicated are close to those presently recorded on nearby fishing grounds. This data series thus appears more conclusive. Inasmuch as we accept the existence of only one stock in this division, and given the quite plausible assumption that all fleets are in fact working the same grounds, the Cameroonian cpue can be used as a global abundance index. Therefore, the total effort exerted can be calculated on the basis of the total catch. Using this procedure the working party (CECAF, 1978b) assessed the potential optimum catch at 3 500 tons for an effort of 12 200 days at sea and a corresponding cpue of 274 kg/day at sea (Fig. 7). This estimation is about 5 per cent short of the true figure because Ivory Coast's catches in the area (100-230 tons depending on the year) could not be figured in.

Furthermore, scattered information exists as to sporadic exploitation by other, unsupervised fleets. Though such exploitation remains a marginal factor, it is nontheless true that we do not have the total catch available to us and that the potential doubtless exceeds 3 500 tons. This assessment is closer to the lower estimate (4 200 tons) obtained by comparing surface areas. This would appear to indicate that the stock is being fished at near-limit levels and that no substantial increase of the total yield should be anticipated.

To the South of this division, off the coasts of Equatorial Guinea and northern Gabon, shrimp grounds have been identified between Cape Esterias and Cape Lopez (Fontana and Ba, 1973). They cover a total area of approximately 200 mi^2. Exploratory surveys conducted in 1969 with a 650 hp trawler gave a yield of 23 kg/h of whole shrimp for the one-year period. According to Garcia (1977) the relative fishing power of this vessel would be one and a half times that of the Abidjan shrimpers. The comparable yield would thus be 15.3 kg/h or 275 kg/18-h fishing day, a very low figure for an unexploited stock. If we compare it to the figure of 435 kg/day obtained in Ivory Coast at the outset of this fishery, the exploitable density would be 1.6 times less. Since the area is twice as small, the potential catch could well be 3.2 times less than that of Ivory Coast, or about 350 tons/year.1/

4.5 Gulf of Guinea (southern) Division

This division fronts the southern coast of Gabon, Congo, Angola (Cabinda) and Zaire. Shrimp is found in this division, as well as further south off the coasts of Angola, but at such low densities that up to now there has been no reason to contemplate the creation of specialized fisheries.

5. CONCLUSIONS AND COMMENTS

The per division assessments have been obtained either by using Fox's model on catch and corresponding effort statistics or by extrapolation from the total area of fishing grounds divided by divisions to obtain the mean sustainable yield per unit of area for the closest assessed fishing grounds. Obviously the figures obtained by extrapolation are less reliable than those derived from direct assessments.

The causes of error are many. Maximum yield per unit of area appears to vary from one ground to the next. This can entail substantial errors in extrapolations, but stratification by divisions ought to reduce this risk. The most delicate item may well be the question of estimating the areas of fishing grounds and the criteria for determining their boundaries. It is not at all sure that all authors have used the same criteria. The bathymetric limits of the distribution of the species, however, are both well defined and well known. The geographic boundaries of the species followthe boundaries of the mud bottoms quite closely. The risk of error in estimating the potential trawling area ought therefore to be rather low.

1/ According to recent information given by Fontana (pers. comm.) this estimation is probably underestimated

Another factor which can alter the assessments, or in any case render them less comparable from one sector to the next, is artisanal fishing, which cuts off the migration seaward of juveniles at the root - as they attempt to leave the lagoons and estuaries.

Sometimes, in order to figure the total potential of a given division, we have merely added together the artisanal yield and the estimated potential of the shrimp during the marine stage. This means that these estimations are only valid for the present level of exploitation of juveniles. In fact any modification in this rate of exploitation would logically entail a change in the recruitment into the marine stocks which would affect the potential yield at sea. The studies made in Ivory Coast (Garcia, 1977) using simulation techniques on a Ricker model did show the following, however. For levels of exploitation at sea and close to maximum yield, a 0-50 per cent fluctuation in the rates of exploitation of juveniles in lagoons (percentage of offtake in number of specimens at the time of migration) had very little effect on the overall sea + lagoon yield. If this observation can be generalized to the Gulf of Guinea as a whole, then the assessments in this work should be relatively independent of the offtake rate from artisanal fishermen.

These findings are summarized in the following table:

Division	Potential (marine phase) (tons)	% of total yield assessed by yield model	Simultaneous artisanal yield (tons)	Global potential under present conditions of exploitation (tons)
Cape Verde (inshore)	2 980	98	2 250	5 230
Sherbro	1 800	100	340	2 140
Gulf of Guinea (western)	2 750	46	nil*	2 750
Gulf of Guinea (central)	3 500(+)	100	500	4 000(+)
Gulf of Guinea (southern)	350	0	nil*	350
TOTAL	≈11 400	82		≈14 500

* Simulations were made on a Ricker model of the theoretical total yield under conditions of no artisanal fishing, which is not the actual case

The total potential (sea + lagoon) of the CECAF area would thus total 14 500 tons for a total area of fishing grounds at sea covering approximately 3 600 mi^2. Mean productivity varies greatly from one fishing ground to the next. The reasons for these variations have yet to be elucidated. It would certainly be very helpful, in terms of utilizing these indexes to productivity in making assessments by comparison, to know them.

Fishing grounds	Mean productivity[b/] (tons/mi^2/year)	
	Present production at sea	Global[c/]
Saint-Louis	1.6	2.2
Roxo-Bissagos	9.4 - 11.8	17.6 - 22.0
Sierra Leone/Liberia	4.5	5.3
Ivory Coast[a/]	1.4	3.2
Benin-Nigeria-Cameroon	(probable) 2.4	(possible) 2.8

a/ At current levels of exploitation in lagoons, the maximum catch at sea would be roughly 570 tons (Garcia, 1978)

b/ At optimum levels of exploitation

c/ Adding the catch in lagoons or in the simulated absence of artisanal fishing

The Roxo-Bissagos fishing grounds clearly emerge as the most productive sector, whether artisanal fishing is taken into account or not. It is not possible at this time to demonstrate the reasons for this, but a certain number of factors which might explain this anomaly can be put forth:[1/]

(a) this fishing ground is located in a zone of very heavy rainfall;

(b) the inshore hydrographic network, the most dense of the entire Gulf of Guinea, is basically made up of drowned valleys or rias. Marine penetration inland is much greater in a network of this type than in the case of a classic river. One effect is a much more extensive sea/freshwater interface. A consequence of this is the extent and density of mangroves and another is nurseries for juvenile shrimp.

(c) the waters covering this part of the shelf are substantially enriched by inputs from rivers as well as from the Senegalese upwelling located due north from December-April and, at the same time, the shorter, less intense, more localized upwelling South of Cape Roxo, i.e., in the immediate proximity of the area under consideration (Rébert, now being drafted).

Of course these assumptions have yet to be proven. In particular, the role played by the size of the nurseries (area, population densities, etc.) as this affects the yield potential and length size of marine populations. One comment we can make is that, if the first of the three explanations put forth above is correct, higher productivity may be anticipated in the Nigeria-Cameroon sector.

1/ According to the information obtained after the drafting of this report it appears that the area of the Roxo-Bissagos grounds used here could be underestimated

Except for the Roxo-Bissagos grounds, the global productivity per unit of area of the other fishing sectors differs at most by a factor of only two. Since logic dictates that variability within each statistical and ecological division should be less than that of the Gulf of Guinea as a whole, it is reasonable to assume that the order of magnitude of the estimations obtained by comparison should be accurate.

Moreover, the proportion of the total potential extrapolated by comparison with the productivity of other fishing grounds is no more than 18 per cent. This low figure, the foregoing observations on the possible variability of different fishing grounds within the same division, and lastly the rather exact data available on the different fishing grounds and their configuration allow us to conclude that the final estimation of 14 500 tons for the Gulf of Guinea as a whole must be correct, or at least as correct as the various individual assessments obtained from using a global model.

6. PROSPECTS FOR DEVELOPMENT

It would be important to identify what proportion of the potential yield, based on the findings of this study, are presently being fished. The global potential can be estimated by adding present catches in lagoons to the potential at sea. The mean present catch corresponds to those data available for the last two years (Table 1).

Strictly speaking, the level of exploitation, as related to the potential defined, for instance, as the peak of the yield curve (MSY), should be expressed in terms of actual present effort and maximum theoretical fishing effort. In our case, the data on total effort are lacking for several divisions, or else are quite haphazard. Penaeidae being rather short-lived fauna (maximum life expectancy = 2 years, mean duration of the exploited phase = one year) when the mode of exploitation is stable and uniformly distributed throughout the year, the annual catch should be nearly equilibrated and therefore the risk of error remains rather small.

Division	Global potential (sea + lagoons) (tons)	Present mean (tons)	% of potential caught
Cape Verde (inshore)	5 230	5 400	106
Sherbro	2 140	1 620	75
Gulf of Guinea (western)	2 750	unknown	unknown
Gulf of Guinea (central)	≃ 4 000	4 000	≃ 100
Gulf of Guinea (southern)	350	0	0

The Cape Verde (inshore) division is fully exploited; in all likelihood above the economic optimum.

The Sherbro division could sustain a slight increase in effort, but the marginal increase of the catch would be low.

In the Gulf of Guinea (western) division, only the Ivorian fishing grounds have been carefully studied. The available data are not enough to determine the current level of exploitation. Ivory Coast exploits its own resources to the hilt. The same is probably true of Benin. We are still not sure about Ghana. However, the very pessimistic conclusions of the Working Party (CECAF, 1978b) must be noted at this point. It does indeed appear that the closing of the mouths of the major lagoons in the country have resulted in the virtual disappearance of marine concentrations of commercial interest.

Despite the persistent doubts due to the poor quality of available statistical data, the Gulf of Guinea (central) division does appear to be fished to maximum capacity.

To the best of our knowledge, the Gulf of Guinea (southern) division remains virtually unexploited, but its resources are comparatively very meagre in terms of both abundance (2.5 per cent of the total potential of the region) and densities.

In short, all stocks appear to be exploited at levels close to the maximum sustainable yield and in many cases at levels exceeding the economic optimum. In those sectors where an increase in the total catch is still possible, the only outcome would be a low, marginal yield. If new prospects for the development of this fishery were to be sought, the search should be in the direction of new species: *Parapenaeopsis atlantica*, and, inasmuch as it is possible to catch and market the species economically, the very small (LT < 7-8 cm) Caridae *Palaemon hastatus* seasonally abundant in very coastal zones and also eventually *Parapenaeus longirostris* over the shelf. Prospects, in any case, remain very limited.

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CHAPTER V

RESEARCH AND MANAGEMENT PRIORITIES

by

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ORSTOM Oceanographers

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1. INTRODUCTION

Although there are some serious gaps in our knowledge of the fishery resources of the region, an examination of their state of exploitation shows that the process of exploiting them commercially can now be considered as more or less achieved. Exploitation of the more interesting stocks has sometimes been excessive, as is attested by certain drops in production following on the intensification of fishing. Better support for the local fisheries, therefore, does not lie in an increase in their means of exploitation but in its adjustment and maintenance at levels that will guarantee a high production at the lowest possible cost. Even where, on a strictly biological level, production could be increased, the main possibilities of growth can be expected to come from two types of measures:

- a better distribution of fishing effort in relation to those stocks accessible to the same fleets and

- a better use of catches, particularly by a better commercialization of the fish that are still discarded.

Even in the richer northern sub-tropical sector, the very substantial possibilities for the development of the local fishery will not be fully realized unless there is an expansion in the production capacity of the coastal countries that goes hand in hand with a reduction in the activities of the foreign fleets.

Little, however, has been done up to now to directly control the level of exploitation of stocks in the region and to improve the distribution of production capacities in relation to the various stocks available. The few economic analyses that exist show that for many of the most sought-after stocks, the benefits to be derived from such measures would be considerable. For the cephalopod stock in the northern sub-tropical sector, for which such analyses are available, the actual net profit to the coastal countries could be increased several times if the fishing effort were brought up to a reasonable level (Christie, 1979; Griffin, Warren and Grant, 1979).

In any case, many studies still have to be done to transcribe the result of assessments realized into management measures that can be directly applied (FAO, 1979). However, measures that are of indubitable interest for the productivity of the fisheries could still be adopted on the basis of the work already published: control of certain mesh sizes, blocking of investments in fleets operating on stocks identified as being fully or overexploited; reduction in the number of fishing licences granted to foreign fleets by those countries that are increasing their own catch capacities, etc. The first section of this chapter will be devoted to an examination of the management plans which seem to be essential and to a discussion of the work that still has to be done to facilitate their implementation. In any case, there is no doubt about the fact that any decisions as regards management, as well as any decisions on the fishing programmes to be put into operation, will depend greatly on the quality and the completeness of the information on the stocks and the fisheries involved. In this connexion the current lack of precision in assessment and the resulting lack of clarity in the procedures and priorities of the measures to be taken, create grave risks for the future of the local fisheries.

Before coming to this point, it is worth remembering that the good management of resources depends also on the setting-up of surveillance and inspection plans that are well adapted to local conditions. Although this is a fundamental point, it is outside the scope of this summary and so will not be dealt with here.

Improvements in our knowledge of resources and thier exploitation depends, of course, on the setting of priorities in research. At various points in the course of this work, the urgent need for certain studies has been stressed. Among these, the need to improve the collection, transmission and dissemination of statistics on fishing; the study of the patterns of distribution and migration of stocks; the economic and social aspects of management (starting with the determination of the optimum levels of exploitation), the multispecies approach to the evaluation of demersal communities, and the determination of the age of pelagic species (which is a condition for their evaluation by means of analytical models, etc.) have all been specifically cited at one point or another. The second part of this final chapter will be devoted to an examination of these priorities.

Accurate identification of priorities in the matter of research seems all the more crucial in view of the fact that the coastal countries usually only have very modest research capabilities which, taken overall, are quite insufficient in comparison to what would be indispensable to ensure the good management of their resources. Furthermore, the way the work is divided up is far from being ideal. We have, for example, noted that up to now the research effort has not always been directed into activities based on the actual economic importance of the different stocks. Thus, compared to their size, the stocks which live in the northern and southern sub-tropical sectors (especially those in the latter sector), are still less studied than the resources of the Gulf of Guinea itself. In the Gulf, the stocks and the bionomy of the permanence zones, and particularly the role of terrigenous supplies on the productivity of the coastal ecosystems, are far less well known than the ecology and the fish productivity of the alternation zones.

2. MANAGEMENT NEEDS

2.1 Regulation of Rates of Exploitation

This is the only measure that will permit the adjustment of catches to the productivity of stocks and, more precisely, to obtain in the long term, catches which will remain close to the maximum of the excess production. It is thus the only intervention which can simultaneously affect the costs of exploitation and, thus, to maximize the profit which can be expected from the fishery. But it is also the measure which, in theory and in practice, incurs the greatest difficulties in application.

Its objective is to control fishing mortality, F. As this parameter cannot be measured directly - that is in real time - it has to be controlled indirectly by interventions on:

- fishing effort, f (by the limitation of fishing effort) or on
- production Y (by the application of quota systems).

The two parameters f and Y are in effect, in principle, proportional to F since, if biomass B, recruitment R and the capturability q remain constant - which, in particular, presupposes a situation of equilibrium - we will have:

$$F = \frac{Y}{B} = qf$$

In practice, we find that these constants suffer from deviations or fluctuations which, little by little, make these equalities inexact. In the short term, however, these equations are, in general, usable, provided that one can follow, in each fishery, the evolution of the terms of the equation.

It has been observed that when one is dealing with animals with a short life such as the penaeidae shrimp, cephalopods and, perhaps, some tropical species of fish, a regulation by annual catch quotas can turn out to be insufficient (FAO, 1977). In fact, each fisherman in trying to gain a growing part of the overall quota, will try to increase his means of capture and above all to concentrate his operations more and more immediately after recruitment. The same total capture will then consist of growing numbers of individuals that are younger and younger, which will lead to parallel increases in the mortality by fishing. In such a situation, regulation will not achieve the desired - that is to say a halt in the rate of exploitation. There is even a risk that it can become harmful at the economic level. In fact, there is nothing to prevent investments considerably exceeding the level of what would be necessary if fishing operations could be uniformly spread over an entire year. This difficulty could, in theory, be avoided by the establishment of quotas based on a shorter period (by quarters, for example), chose in such a way as to best spread exploitation over the annual cycle. Nevertheless, such legislation still remains difficult to apply.

Regulation of the rates of exploitation by the control of the fishing effort, e.g., by limiting the means of capture, avoids these difficulties. It prevents not only the biological overexploitation of the stocks, but also - and this is not its least advantage - minimizes the cost of the catch. Limitation of effort also permits one to get the best part of the inter-annual variations of abundance resulting from those of recruitment, without (theoretically) having to worry about adjusting the fishing effort from one year to the next. In any case, in the event of overestimation of effort in relation to the optimum level of exploitation aimed at, such a method of regulation does not cause the damage which would result from a regulation by catch quotas in the case where the average maximum catch had been overestimated (Walter, 1976).

Bearing in mind the short life-span of numerous tropical species on the one hand, and the possibility of controlling catches and costs of exploitation on the other hand, preference should be give to regulations applied to the means of exploitation. This would not rule out having recourse to supplementary controls such as catch quotas, for example, if these should become necessary in order to momentarily stop an exploitation that could become excessive for some particular stock (or for any other reason).

At the operational level, the use of catch quotas to control the mortality by fishing, also presupposes that the authority in charge of management knows in good time of the catches that have actually taken place. The difficulties that the coastal countries encounter in knowing the nature (species) and the catches actually realized by the various fleets operating in their exclusive area (particularly as regards the sampling of their own artisanal fishery and checking on the activity and performances by the foreign ships operating under licence) all work in favour of their having recourse to the limitation of effort. This could be done, for example, by having a quota system for the number of boats in the national fleets and also (in those countries where the question arises), on the number of licences granted to foreign ships. Such licences should quite clearly lay down the limits in size and other characteristics that may affect the fishing power of the ships, as well as the type of fishing (gear) allowed and the species that they are authorized to catch.

Such a method of regulating would not do away with the need to collect statistics on catches. It is, in fact, important to be able to check that the ships are exploiting well those stocks to which they have authorized access by being able to refer, in particular, to the specific composition of their catches and to the reports entered in the ships' logs. It is essential, in fact, to be able to stop any inopportune shifting of the activity of the fleets from one category of stock to another and any concentration of fishing effort on reserved stocks or the use of some particular gear or mesh whose use is restricted to other stocks. Thus, for the trawlers, there could be regulations on what bottoms are open to boats fishing for shrimp, which are open to the fishing of mullet or to trawlers carrying out a specialized fishery; i.e., coastal trawlers exploiting the coastal communities, high sea trawlers operating on the deep water communities, trawlers fishing for pelagic fish, etc. Each fleet could be identified through markings that could be easily recognized by the ships or aeroplanes that have to carry out the surveillance. This surveillance should normally be completed through an inspection (both on land and at sea), of the specific composition of the cargoes. Such inspections would be facilitated if the boats were based at, and operating from, local ports. This is a point which, when added to other advantages of reducing costs and developing new activities and new employment through trans-shipments and, possibly, the processing of the product, should encourage the coastal countries to try to reach agreements with their foreign partners that will provide for the regular transit of ships in the ports of the area.

The control of exploitation rates by limitations of the fishing effort also implies that the performances of the various categories of ships be evaluated and followed up, particularly as regards improvements in efficiency which will certainly take place as a result of technological innovation (improvement of fishing power) or from changes in the relative space-time distribution of fishing operations and stocks (improvement of the capturability coefficient). In principle, the yield of each category of ship in each fishery can be determined on the basis of observations of performances from sampling of the ships. This possibility can considerably simplify the collection of data. In any case, this collection remains indispensable in order to periodically take into account any gains in efficiency when determining the overall number of licences.

We can thus see that even if the regulation of the fishing effort can, at least initially, be satisfied with rough statistics on catches and yields, the need for an efficient statistical system seems just as indispensable for good fishery management as it is for the evaluation of resources.

2.2 Protection of Young Fish

We know that it is possible to improve yields quite considerably by delaying the catch of young individuals in each cohort until they reach an appropriate age. As this does not affect the rate of exploitation, such regulation cannot, in the long run, prevent the cost of exploitation for all the fishery from becoming excessive. It can only be considered, therefore, as a complement to the regulation of the rate of exploitation. In fisheries where particular gear, such as the trawl, can act selectively on the size of the individuals, the protection of the young can be carried out through the prohibition of mesh sizes of less than a predetermined size. In all the fisheries, it is also sometimes possible to prohibit fishing when and where the fish of a size smaller than the size of first capture are particularly abundant.

2.2.1 Regulation of net mesh size

The recommendations laid down by CECAF and the current conditions of their application have been reviewed and discussed in Chapter III of this document as well as in the report of the fourth session of the CECAF working group on the evaluation of resources (FAO, 1979). On the basis of this information, the current situation in the matter of mesh regulation can be summarized as follows:

(a) the mesh of the nets used in the main fisheries in the region (fish and shrimp trawls, beach seines, and other towed gear, as well as fixed nets used by the artisanal fishery for shrimp) are generally too small for a rational exploitation of the main target species;

(b) national legislation on the subject of mesh size often has to be publicized and the existing dispositions are still often inadequately applied;

(c) a certain number of conclusions on the evaluation of mesh size are the result of single species studies. When the catch of the species being studied is accompanied by important by-catches, these conclusions are not necessarily applicable to the fishery as a whole. In order to be sure, it is necessary to identify the effects of the measures under consideration on the fishery of all accessory species. This is the case, for example, in the simultaneous fishery of hake and shrimp on the shelf slope of the northern sub-tropical sector.

The action to be taken should, therefore, aim at:

(a) having national legislations reflect the recommendations of CECAF and the national studies that have been made on this subject and the immediate putting into effect of those regulations that can be immediately applied: for example, mesh sizes of 60 mm for the fishing of cephalopods as well as for the fishing of tropical and sub-tropical coastal communities (0-50 m);

(b) undertaking investigations to determine the specific composition (in number and weight), of the catches and discards in the multispecies and multigear fisheries: this applies particularly to the deep water hake/shrimp fishery on the slope in the northern and southern sub-tropical sectors; the fishery for penaeidae shrimps and the accessory fish species that are the most often discarded; and, finally, the capture of juveniles by beach seines, and

(c) reviewing, in the light of the data collected in recent years, the evaluation of mesh size for hake and sparid fisheries in the extreme northern zone.

The data on size and age collected in this way will enable the probable effect of any legislation on the various fisheries to be determined: particularly the effect on those fisheries which simultaneously or consecutively exploit the same species according to age.

It is worth noting that, in the case of animals with a short life span, such as the penaeidae shrimp or the cephalopods, the calculations cannot be carried out in the classic manner (in terms of immediate loss and long-term gain on the annual cycle), since the various parameters show important seasonal variations or sudden changes with age (of M,for example, in the case of cephalopods (FAO, 1979)). In the first case, the appropriate time scale for the calculations (a month or three-month period at the maximum) is less than the annual biological cycle; it is therefore necessary to have recourse to simulation techniques. In the second case, as the biological parameters do not remain stable with age, it is necessary to have recourse to a Ricker model.

2.2.2 Closed seasons

The results that can be expected from closed fishing seasons, in sea and lagoon, whether simultaneous or not, have been studied for shrimp in Ivory Coast (Garcia, 1977 and 1978); and the results depend very much on seasonal variations in capturability. Such interruptions of the fishery have also been envisaged by Le Guen (1972) for the fishery of *Pseudotolithus (Fonticulus) elongatus* in the Congo. Griffin, Warren and Grant (1979) have studied the economic effect of similar interventions on the fishery of cephalopods in the northern subtropical sector.

Apart from these few cases, there are a few studies that would enable us, at the present moment, to assess the advantage to be gained from this kind of regulation. The advantage, in fact, would appear to be moderate when we consider that it is quite complicated to apply the surveillance and inspection facilities of the coastal countries which are still very modest.

2.2.3 Protection of nursery areas

Most of the nursery areas feeding the coastal stocks are found in the littoral areas within the field of operations of the artisanal fishery. This is the case of more or less amphibiotic species such as shrimp and certain croakers, as well as sea bream, mullet, sardinella, bonga, various carangids, rock lobster, etc.

The exploitation of the juveniles of these species by artisanal fisheries is often considerable and still only followed up very summarily whether the result in mortality is intentional (shrimp, sardinella) or by chance (discarded species). If the traditional line fishery did only slight damage to the juveniles of these species, this is no longer so, since in certain countries the artisanal fishery has now developed and modernized (purse seines, artisanal seiners and trawlers, etc.). If a modern artisanal fishery, whose moderate efficiency is liable to be counterbalanced by the numbers involved, is able to enter coastal zones previously reserved for traditional fishery, the danger of overexploitation of stocks at the level of the juveniles becomes very real.

The nursery areas should also be protected from indirect attacks such as pollution. The localization of areas of concentration of juveniles should be taken into account when selecting sites for industrial plants that may pollute, or urban developments, etc.

The management of river basins (irrigation, antisaline weirs, etc.) is also liable to affect the biotic capacity of certain nursery areas and thus the recruitment of species such as penaeid shrimp, bonga and, perhaps, the flat sardinella.

The best known case, and perhaps the most critical, of conflict between the fishery of juveniles and adults is that of the exploitation of the *Penaeus duorarum* shrimp. The artisanal fishery for this species in estuaries and lagoons removes, in fact, very large numbers of individuals that have not yet reached their sexual maturity. The juvenile fishery is carried out with the help of fixed or trollnets. In the first case, the juveniles, having terminated their first stage of growth, are captured passively during their migration toward the sea where their sexual maturation takes place. In the second case, catches affect juveniles that have not yet terminated their lagoon phase. In these two cases, this fishery brings about a considerable reduction of recruitment to the marine stock. It can be supposed that at the age when these shrimp are caught, the most important natural mortality (during the larval stage in particular) has already taken place. Because of this, the reduction (in numbers) of recruitment potential will lead directly to a proportional reduction to the catch potential in sea (in weight). It is thus clear that the average maximum catch at sea would be achieved by the total elimination of the artisanal fishery. But in view of the social importance of this fishery, it is equally evident that its complete elimination can only be contemplated with the greatest difficulty. On the contrary, it would, theoretically, be possible to stop the sea fishery while preserving the artisanal fishery. Nevertheless, this extreme solution is not advisable on economic grounds and the impossibility of having an indication on the abundance of breeding species available at sea could lead to the risk of extinction.

From a purely economic point of view, the increase in the pressure of fishing on juveniles brings about a reduction in the unit value of catches by lowering the average size of the individual. This drop then puts them in direct competition with the carids of the cold seas whose price make them so competitive on the world market.

Other criteria such as the respective investment costs per ton produced in the lagoon and sea fishery (including foreign currency); the respective exploitation costs; the number of jobs created in rural or urban areas (and their respective costs); the distribution of profits coming from the fishery between the various groups of fishermen, etc. All these have to be taken into consideration in determining a rational exploitation plan for shrimp stock (Troadec, 1978).

While waiting for such analyses to become available, a reasonable balance between the two methods of fishing should be encouraged. Study of the evolution of the total catch (sea + lagoon, in tonnage and value), in relation to the various combinations of exploitation rates in the two fisheries, is complex and requires the use of simulation techniques. A study of this type carried out by Garcia (1977) on the Ivory Coast stocks has shown that, for sea levels close to full exploitation (which is actually the case nearly everywhere), variations of 0-50 per cent in the exploitation rates in lagoons (in relation to present overall level) would only have slight influence on the total catch (in weight), but could appreciably change its value by improving it (from 12 to 40 per cent). This result cannot necessarily be applied generally to all the stocks of the area. In fact, it depends greatly on the evolution of capturability with age and on seasonal variations in capturability connected with local hydrographical conditions.

In countries where the artisanal fishery in littoral zones is already intensive and liable to develop rapidly (this is notably the case in the extreme northern zone) it is therefore most urgent to consider the formulation and adaptation of measures aimed at limiting the mortality due to the fishing of shrimp and fish juveniles. Appropriate measures to protect the marine recruitment of shrimp could include the following:

(a) control of the mesh of fixed shrimp nets in order to avoid catching individuals that are too small and thus difficult to sell. The individuals protected in this way would thus participate in recruitment to the marine stock;

(b) strict limitation or (probably even better), the total prohibition of trollnets as their use on shallow bottoms causes, especially if their mesh is small, the destruction of considerable quantities of juvenile shrimp without commercial value;

(c) regulation of the number of fixed nets authorized at each outlet in order to avoid too strong a concentration in bottlenecks (narrows, bridges, etc.) where the capturability is greatly increased;

(d) finally, closed season for the fishery during the seasons when the migrating shrimp are particularly small (period of growth). Generally these are the periods of greatest abundance and recruitment to the sea would therefore be assured. This closure could (if the utility of such a measure could be proved), be completed by the simultaneous suspension of sea fishing in order to improve even further the recruitment for this fishery.

2.3 Management of Multinational Stocks

Management of stocks that are spread over, or migrate over, more than one exclusive economic area cannot be assured unless the countries in charge of their exploitation agree, first of all, on the catch that is not to be exceeded each year for each stock as a whole; and then on the sharing between them of whatever profits result from their exploitation.

In the northern sub-tropical zone, the number of stocks in common is very high. This is because of the long migrations and the extent of the areas of distribution of stocks which, in this sector, are particularly large as compared to the extension of the coastal fronts of the coastal states. Among the stocks which can be called common, CECAF has identified:

- various demersal stocks of the northern sub-tropical sector: hake, cephalopods, various species of sparids, etc.;

- coastal pelagic stocks of the same sector: round sardinella, horse mackerel, mackerel, blue fish, etc.;

- the stock of penaeid shrimp situated off Cameroon and Nigeria (FAO, 1978).

To this list has to added the coastal pelagic stocks of the southern sub-tropical sector (South Gabon, Congo, Zaire, Angola). It is for coastal pelagic stocks that the problem of management is the most critical. In the northern sub-tropical zone, for example, their migrations mean that hundreds of thousands of tons travel over distances that can be up to 1 000 to 1 500 km, that is to say, they pass along the coastal fronts of five or six different countres.

CECAF devoted a special meeting to a study of the principles and procedures of managing such stocks (FAO, 1979a). This meeting stressed the fundamental importance of having information on the geographical distribution and seasonal changes in the distribution of the biomass of stocks as the basic document for any negotiations on the division between the coastal states of the catch or of the overall profit. Such information could be gained from:

- survey campaigns on the biomass, by trawl or by acoustic detection, spread over various seasons and over all the area of distribution of the stocks, or by

- fishery statistics (cpue) for the main fleets.

3. RESEARCH WORK TO BE DONE

The work to be done derives directly from the priorities defined for management and the current state of our information.

3.1 Improvement of Fishery Statistics and Biological Data

While undeniable progress has been realized in recent years both in the gathering of fishery statistics by the fishing countries and by their transmission to CECAF, the poor quality of some, and the inadequate breakdown of others, together constitute the main stumbling block for the improvement of assessments of fishery potentials in the region. To achieve a continuous, satisfactory control over the main parameters of stocks and fisheries, efforts should mainly be made in three directions:

(a) Expansion and consolidation of the CECAF statistical system

CECAF has defined and implemented a system of statistics which defines the nature of the data (catches, cpue and distribution), the standards for the gathering, compilation and transmission of statistics of area interest as well as the priority of the parameters to be measured (Ansa-Emmim and Levi, 1975; FAO, 1979). Moreover, it has probably assembled in its archives and in the reports from the Working Groups, the essentials of the data existing in national fishery services and national laboratories. With the exception of a few countries, there is thus more to be gained from a consolidation of the system (first of all at a national level) than in the collection of any outstanding data. A particular responsibility rests with the coastal countries for the full implementation of this system. Because of their new responsibilities, the collection of data will one day or another be done by exclusive economic zones within which each coastal country will collect the data relating to its own fleets, and those of any of its foreign partners, and then forward them to the regional body. This observation shows just how urgent the need is to strengthen the capacities of the administrative and statistical services inside the countries of the region.

(b) Improvement of sampling of artisanal fisheries

The data concerning this fishery are still very rough; at worst they are clearly biased, or even non-existent. With a reasonable investment in materials and personnel (investigators) and the perfectioning of suitable sampling techniques (for which a temporary technical assistance may be needed in the short term) satisfactory data could be collected regularly on this subject. In particular, each country should prepare a yearly census aimed at evaluating and following up the size of its canoe fleet as well as its distribution along the coast. Information on the frequency of expeditions, changes in the gear used and the target species, as well as on the yields obtained, should also be collected on the same occasion.

Effective management of the artisanal fishery, therefore, depends on the setting-up of a permanent sampling network (investigators), according to a suitable statistics programme. This programme should be able to benefit from the technical training of competent personnel and have available the means of processing (organizer) appropriate to the importance and diversity of the information collected. Such a complete system is, of necessity, costly. It would not be justified except in those countries where the artisanal fishery represents (either already or potentially) an appreciable socio-economic activity (Senegal, Ghana,for example).

(c) The gathering of statistics on the fishery of foreign fleets

Over the past ten years, CECAF has come up against very serious difficulties when it has been a question of obtaining statistics, conforming to the standards of its system, from some countries that are foreign to the area. In order to correctly manage the resources which belong to them, the coastal countries have an imperative need to know, and to check, the location of the activities and the performances (species, sizes, yields) of foreign fleets operating within their economic areas. The strengthening of their authority is certainly a factor which should contribute to an improvement in the reportings. On the other hand, it is going to be necessary to collect data according to more fine geographical networks and there are, as yet, very few countries which have available the statistical and surveillance services that possess the expertise and experience needed to draw up and then implement such programmes. Such an evolution would not, in any case, eliminate the need for a regional mechanism dealing with statistics. Coastal countries will, in effect, always have a need to exchange data relating to the stocks that they exploit in common, whether it is for their assessment or to ensure that each partner carefully adheres to the restrictions that were mutually accepted. For these stocks, and also for the national stocks when the setting-up of distinct statistical systems for the latter does not have any advantage, the coastal countries should consult together regularly to draw up standards that will ensure compatibility so that the data can be processed.

3.2 Surveying of Resources

The difficulties that currently hinder the gathering of complete and accurate statistics will not be overcome easily or quickly. While still trying to improve the functioning of national statistic systems, the regular carrying out of survey campaigns will provide trustworthy indications on the abundance of the main stocks. Such indications can be supplied by trawling surveys for the demersal species and by acoustical methods - quantitative or not - for the others. The state of the stocks could, therefore, be followed, which would allow for an intervention as soon as the drop in the biomasses seemed excessive. The "Guinean Trawling Survey" (Williams, 1968) is a good example of what can be done in this way for demersal resources. Its interest for the assessment of demersal resources has been shown by the use which has been made of it in this study of the results it supplied. Numerous echo survey campaigns carried out during these last few years by FAO and ORSTOM in the area have likewise shown the usefulness of this method and how these campaigns can best be carried out in the region.

Such campaigns have a secondary interest. The information calculated on the distribution of biomasses and the seasonal exchanges between exclusive economic zones that they provide are, in fact, liable to assume a fundamental importance during negotiations to draw up possible methods for the division of the production between states (FAO, 1979a). In particular, the information they supply is normally of better quality and less open to discussion than fishery statistics (the cpue of various national fleets,for example).

Surveys are also capable of giving information on the identity and distribution of certain stocks - for example, the main demersal communities. This type of information is of great usefulness in deciding the breakdown of data during the assessment of stocks. Finally, trawling surveys would allow for an assessment of the relative abundance of species currently discarded, and thus see what possibilities there are of improving the utilization of the various demersal communities in the area.

3.3 Multispecies Assessments of Demersal Communities

A major characteristic of demersal tropical resources is the fact that there are so many species involved. Contrary to the cold water or temperate sea fisheries, which only aim at one or two particular species (FAO, 1978), the tropical fisheries try to obtain the best yields with a group of major species that can often number more than a dozen, and then with secondary species that could represent more than half of the supply at landing. Furthermore, the proportion of discards is often very high, and this affects both the small size species and the small individuals of the commercial species.

A structural multispecies approach in the assessment of such stocks is not possible for reasons that are both practical and theoretical. The research work implied would, in fact, call for means that are way above those that one can hope to mobilize in the near future. Furthermore, even if studies on growth and selectivity are well advanced, and one can hope to assess, in an acceptable space of time, both mortalities (natural and by fishing) and recruitments, the interspecies relationships are only now beginning to be perceived and it will be a long time before these can be quantified.

A global multispecies approach seems, on the other hand, to be possible. The examples of the application of a global model to the group of demersal stocks fished simultaneously by trawler have, in effect, multiplied since the assessment of the sparid stocks in the northern sector of CECAF (FAO, 1968) or Ivory Coast (Fonteneau, 1971), while Pope (1976, 1979, to be published) has shown that this method has a good theoretical base. In the light of these works, it is clear that to make assessments more precise, greater attention should be paid in future, in practical applications, to the two following basic points:

- multispecies communities should be defined as homogeneously as possible by their specific composition and in the biotic capacity of the environment which supports them;

- the effect, on overall production and yields, of the distribution of available effort over the species that constitute the stock.

In order to better define the elements in the stocks, studies on the geographical distribution of demersal communities that have already been identified, and on the cartography of the nature of the bottoms, should be taken up again and completed. Furthermore, due account must be taken of the distribution of the big ecological groups, and particularly the distribution of the main hydrographical phenomena - upwelling, terrigenous supply, currents, etc. - capable of having an appreciable influence on the biotic capacity of the environment.

With regard to the second point, Pope *(op.cit.)* has formulated a global model for several species and shown that it is possible to optimize the average maximum of production by playing experimentally (through gear, time-space distribution of fishing operations, etc.) with the specific compositions of catches and thus on the division of effort on the various species making up the multispecies stock.

Regular survey programmes would be capable of supplying information complementary to the fishery statistics and needed in order to take into account these fundamental aspects. These programmes would, in effect, allow for the definition of unitary multispecies stocks, that is to say, the units of application of the assessments. They would then permit a comparison of the specific composition of the catches of commercial fleets - including discards - and their evolution in time to those of the biomasses estimated by surveys. This last point is very important since, according to Pope's first conclusions *(op.cit.)*, one can hope to improve the exploitation plan (division of effort on the species) by making an effort to maintain, whatever may be the level of exploitation, the specific composition of the biomass as close as possible to what it was at the beginning of the exploitation.

3.4 Selectivity

Section 2.2.1 describes in detail the studies which condition the formulation of regulations on mesh size and their conditions of application. Without repeating the points already made on the subject, it is worth recalling here that among the works to be urgently undertaken the following have been identified:

- assessment of the meshes presently used.

- observations on the specific composition of by-catches. Such observations are necessary in order to take into account the catches of accompanying species when the results of the evaluations of mesh sizes are being transformed into regulations and to define the conditions of their application to the various fisheries.

Here, too, the multispecies nature of demersal stocks requires a particular methodology if we wish to determine the suitable mesh size for the simultaneous exploitation of these groups of species. The method followed by Fontana (1974, 1979), who integrated into a Ricker model the results of the exploitation of six species representing about two thirds of the catch landed at Pointe-Noire (Congo) by the trawlers, gives a good example of how this problem can be solved.

3.5 Inventory and Study of Nursery Areas

In order to determine what zones to protect from an inconsiderate artisanal exploitation or from the damage by pollution of an urban, industrial or agricultural development, the mapping of the nursery areas must be rapidly undertaken. These studies should begin with the estuary and lagoon areas, that are particularly rich in nurseries but also extremely vulnerable, to continue then with certain rich coastal sectors such as the Petite Côte to the South of Cape Verde or the Arguin Bank. Conservation plans for these environments - possibly through the creation of national parks - and the protection of juveniles - through the prohibition of fishing with dragnets, or the limitation of mesh size, etc., should then be examined.

3.6 Overall Study of the Ecosystems

Various research work carried out these recent years has highlighted the importance of factors other than fishing, particularly climatic and hydroclimatic factors, in long-term changes in the abundance of resources (see for example Cushing, 1975). These results are fundamental, in the sense that if management of resources aims at adjusting the parameters of the exploitation of an ecosystem to get the best part of its production function, this remains tied to climatic factors particularly through recruitment. Good management, therefore, depends on a better overall knowledge of the ecosystem and the mechanisms which control it. The means available to the area both in men and equipment, do not at present allow for any intensive research in this field to be considered. Nevertheless, some support has already been given by international organizations - such as Unesco - for the study of terrestrial ecosystems, in the framework of the "Man and the Biosphere" programme, for example. It would, therefore, be worth looking to see how these programmes could interest also the marine ecosystems, particularly those along the coastal strip.

In the meantime, certain aspects of the evolution of ecosystems should be studied quickly, i.e.:

(a) The effects of the hydraulic management of rivers

The drought of the seventies, the rise in the price of petrol and the resulting need to promote other sources of energy, particularly hydroelectric energy, the need to reduce cereal imports and therefore to increase the growing of local crops, have all meant that the management of rivers and their estuaries has greatly accelerated in recent years. The management of the River Volta initiated some time ago has been followed by that of the Bandama, which is already well underway. Projects are now being drawn up for the Niger, the Gambia, the Casamance and the Sine-Saloum (anti-saline weirs) as well as the Senegal.

The first consequences have been a drop in the overall annual flow of the rivers, as a result of losses through irrigation and accumulated evaporation and, on the other hand, a drop in the annual seasonal floodings. The second, whose effects are not necessarily any the less on the coastal ecosystems, entails the interruption of migrations, particularly the prespawning migrations of certain marine stocks. The oldest examples of river management involving the Mississippi or the Nile show that the general productivity in the sea and that of certain stocks (penaeid shrimp, bonga, flat sardinella) can be seriously affected by the drop in nutrients and the ecological upset of nearby estuary and coastal zones. For the River Senegal, whose absolute flow has been reduced, the loss in the nutritive supply should, however, remain minimal with regard to the enrichment because of the upwelling. But such is not the case with other rivers for which it would seem urgent to assess, at least approximatively, the consequences of river control work on the coastal ecosystems, as well as on the fishery stocks which these ecosystems support.

Studies concerned in part with this problem have begun in Ivory Coast (Dandonneau, 1973; Binet, 1977). Berrit *et al.* (1977) also underline the importance of river nutrient supplies off the coast of Guinea Bissau. The results of this research are still too fragmentary and localized for one to generalize on the early conclusions.

(b) The specific composition of the ecosystems and the possible effects of their fishery on their evolution

Research work carried out on the coast of West Africa has mostly been oriented toward the assessment of target fish in isolation. Without any systematic assessment campaign on the abundance of the species as a whole, there are little data available or utilizable concerning the by-catch species and, as a consequence, the reaction of the populations to an increase in the pressure of human exploitation has not been followed.

It would seem, however, that the ecosystems have suffered important modifications, of a size and a geographical extent that have rarely been observed elsewhere.

The explosion of the trigger fish stock from Cameroon to Guinea Bissau (Chapter III) is the best example. The collapse of the round sardinella stock in Ivory Coast and Ghana and its subsequent re-establishment (Chapter II) is another. In the latter case, the temporary drop in the stock is now explained as being due to overfishing combined with an exceptional availability, and to an abnormal drop in secondary production and recruitment. To explain the explosion of the trigger fish stock we are still depending on suppositions, some of which are connected to fishing (such as the development of the exploitation of the shrimp in the same biotope), others are related to the effect of long-term climatic variations. It would, therefore, be interesting to see what link in the ecosystem was broken in order to cause this explosion and what modifications in the trophic pyramid correspond to it.

(c) Studies on the environment

In order to define the main ecologic units of the region - the usefulness of knowing about these for fisheries has been shown in the chapter devoted to the assessment of demersal stock (Chapter III) - and to follow their evolution over the long term, the studies need to be carried out on the physical mechanisms which control the coastal ecosystems (upwelling, terrigenous supply, currents, primary and secondary productivities, etc.).

Such studies could also enable us to see certain relationships between the abundance of stocks - especially by the intermediary of recruitment - and the interyearly variability of certain hydroclimatic phenomena. The existence of long-term trends raises a particular problem. Most of the assessments concerning West African stocks are based on observations made over a small number of years. This period, which corresponds to the intensification of the fishery, is centred in the seventies, during which climatic conditions appear to have diverged considerably from the normal (e.g., drought). Lacking a point of reference, it is thus not possible to aprreciate the importance and the direction of the bias (which these recent hydroclimatic changes are probably responsible for) in relation to the long-term averages.

Given the weakness of scientific potential in the region, and the advisability of developing research work by going from the simple to the complex, the laboratories in the area should distinguish between the following when they come to planning their research:

- basic studies (determining recruitment, sketching out of provisional models, etc.). These should be selected and carried out initially by top-level teams that are fully equipped and also highly experienced;

- programmes to improve and regularly measure the indicators on the average conditions of the environment. As far as possible these should be carried out at first with the cheaper and more easily available methods (observations at coastal stations and on the commercial navigation routes, the processing of certain observations coming from satellites, etc.). The comparison of these indicators, at various points on the coast, would be helped by some standardization of the measurements themselves and their processing. These measurements will supply the information on seasonal and interyearly fluctuations that are most urgently required for assessment and surveillance work on the stocks.

3.7 Artisanal Fishery

Studies on the artisanal fishery are most urgently needed in countries where this activity is already developed or is liable to be so soon. The uncertainty surrounding this activity which results from the lack of attention that has been paid to it up to now puts its future at an undeniable risk. The development of the coastal countries is accompanied by a rise in demand and in improvements to distribution (extension of the road network and the refrigeration facilities in particular), which, at the same time, encourage a rapid development of the artisanal fishery in countries where resources permit it. But the impact of this activity, which inevitably concentrates on the stocks along the edge of the coast, must be quickly assessed in order to avoid the risks of overexploitation and to quantify, at the same time, the prospects available for expansion.

Right now, certain stocks, such as those of the spiny lobster *(Palinurus mauritanicus)* in the northern sub-tropical zone, are being ransacked relentlessly and without any control. In Ghana, the artisanal fishery was capable of removing, in a matter of months, almost the entire biomass of the round sardinella, thus bringing about the complete disappearance of this fishery for several years.

The shrimp fishery in lagoons demands immediate attention. In various countries this fishery has grown greatly under the encouragement of intermediaries who carry out the processing and commercialization of the product, and support the fishermen with certain technical help. For several of these stocks, the catching of juveniles already represents the main portion of their mortality by fishing. Studies similar to those carried out in Ivory Coast (Garcia, 1977 and 1978) should, therefore, be started in order to check if the conclusions proper to the Ivory Coast stock can be extrapolated to the overall stocks of the region. We would then be in a position to know what management measures should be taken.

3.8 Interactions Between Fisheries

Artisanal lagoon shrimp fishery and industrial sea fishery are but one case of two fisheries competing for the same resource. Garcia (1977 and 1978) has studied this competition on the Ivory Coast stock. Other similar situations are known although, up to now, they have not been the subject of any very detailed studies. For example, Fréon *et al.* (1978) have described the fishing pattern that the small pelagic stocks (sardinellas, horse mackerel and mackerel) are exposed to in the Senegal-Mauritanian area first by an artisanal fishery for the younger aged classes, then by sardine boats of average tonnage and, finally, by trawlers and deep sea seiners for the older fish.

At the biological level, we can distinguish two patterns of interaction:

(a) that where the various fleets catch individuals that are progressively older and older. In this situation, the fisheries taking the youngest individuals directly reduce recruitment to the older strata that are exploited further on by the other fisheries. The first fisheries will only be affected by the second (and this will only take place with a dela corresponding to a succession of generations), if the latter reduce the parental stock to such an extent that it has a chronic effect on initial stock recruitment. This case corresponds to two examples - shrimp and coastal pelagics - that were mentioned earlier;

(b) a situation where there is simultaneous exploitation of the same stock by two or more fleets whose catches have demographic structures that are relatively close. In this case, the fisheries are in direct competition. Although easy to study at the theoretical level, these interactions have extremely important consequences on the distribution of profit between the different segments of the fishery engaged on the exploitation of a resource: artisanal fishery, national industrial fleets, and foreign fleets working under licence in the same exclusive economic section,for example; or the exploitation of multinational resources by several national fleets working in their respective exclusive economic zones (or not), etc. Here, the increase of activity in one segment of the industry, resulting, for example from the acquisition of new ships, or the release of new fishing licences to foreign ships, will be translated, regardless of the state of exploitation of the stock, into a drop in the size of the latter and thus to a reduction in yields and in the average productions in the other segments. Conversely, a reduction of activity in one segment will be beneficial to all the other segments even if these do not actually change their effort (Gulland, 1968 and 1979).

Up to now, these interactions have largely been ignored in the planning of development and in negotiations with potential foreign partners. But the direct consequences which they have on the division of the profits of the fishery between the various groups of national fishermen - traditional rural communities and crews living in urban areas for example (and possible with foreigners), makes it imperative that their analyses be quickly initiated and completed.

3.9 Socio-economic Studies

In a hunter-prey system such as fishing, studies up to now have been almost exclusively limited to studies on the prey. This orientation of research programmes needs to be quickly extended. The new law of the sea, in fact, gives coastal countries increased possibilities to reduce the costs of exploitation and to work for an improvement in the distribution of the profits drawn from the fishery between the various groups of national fishermen and socio-professional categories.

The studies which would seem to be the most urgent in order to see in what terms the choice lies, are the following:

(a) analysis of the macro-economic aspects of the management of the main fisheries. The aim would be to determine the optimum global level - for social and economic plans - of the exploitation of each resource according to established criteria; possible systems for the division of the product of the fishery of multinational stocks between various coastal countries; the level of participation of foreign fleets; the desired evolution of the latter and the financial contribution (or other), that it might be possible to impose on these partners, etc.;

(b) comparison of the choices available,for example, between artisanal fishery and industrial fishery for the full valorization of each available resource according to different economic criteria (profitability, foreign exchange, etc.) and social criteria, (employment, nutrition, etc.) envisaged and the hoped for division of product of the fishery between the various national socio-economic groups;

(c) an evaluation of the costs and the added value pertaining to the different interventions which follow from the catching of the fish up until its consumption. The purpose of this being to identify obstacles to improvement in the national fisheries and to draw up, in an objective manner, priorities for intervention and assistance.

This long list of studies and research work which should be carried out in order to be in a position to be able to guide the valorization and management of resources in the area, has been prepared in a way that does not let the actual priorities stand out very well. Its length reflects the fact that research work in the area is still at an early stage and that the scientific resources available are weak. The contradiction between the mass of studies to be undertaken and the modest resources that can be mobilized show how a rigorous election of the programme to be carried out is of the utmost importance.

Before attempting to draw up a series of priorities, it is necessary for us to recognize that the amount of the research effort must be adjusted to the richness of the resources and to the role of the fishery in the national economies. The effort must, in particular, be much more pronounced in the two sub-tropical zones which border the northern and the southern parts of the Gulf of Guinea. In fact, fishing in these areas is a major factor in the national economies.

The first priority should be the setting-up, in each country, of structures and programmes that will allow for the routine collection and exchange of the fishery, and other biological and economic data, that are indispensable for keeping control over the state of the stocks and the corresponding fisheries. While waiting for the full realization of this programme, and in order to collect the information on the space-time distribution of the main multinational stocks needed to prepare management agreements, a special effort should be brought to bear on the execution of survey campaigns.

In the short term, a more global approach should be taken in the assessment of stocks and fisheries and the setting-up of management schemes adapted to local conditions. This implies taking into consideration simultaneously various species and different segments of each fishery. This means:

- promoting multispecies assessments;
- studying the interactions between fisheries depending on the same stocks;
- analysing the socio-economic aspects of development and management of the fisheries;
- promoting the study and the control of artisanal fishery;
- charting the nursery areas and studying what measures are capable of better ensuring their protection.

In the long term, and beginning with those countries that are richer in fishery resources as in research capacity, the overall study of the fish communities and the main fisheries which they support must be extended to a study of the ecosystems, and in particular, to analyses of:

- the consequences of river control on the ecosystems and on their exploitation;
- the effects of fishing on the specific composition and the population dynamics of the various populations;
- ecological units, their interannual variability and their long-term tendencies, in order to explore the influence of natural fluctuations on the evolution of fishery resources and their production.

This research work, even the most urgent, cannot be carried out well if the coastal countries do not swiftly strengthen their research potential. This implies not only reinforcement in material and human resources but it is also very often a question too of better integration of national efforts. Having a research team of a certain level, size and of sufficient variety, with a director and all the equipment needed for processing information, and, finally a research ship for surveys represent costly investments and very high operating expenses that only a small number of countries can currently permit themselves and fully utilize. Strengthening of cooperation between countries exploiting the same stocks would give, at much lower cost, a collective autonomy in the matter of research. This presupposes an improvement in exchanges and harmonization of national programmes and, to the extent that it is realizable, the common use of heavy equipment. At the same time, such cooperation would greatly facilitate the complete coverage of stocks spread over various exclusive economic zones when research work is carried out at sea.

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